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MISERS BLUFF SERIES. MISERS BLUFF I AND II TECHNICAL PHOTOGRAPH--ETC(U)

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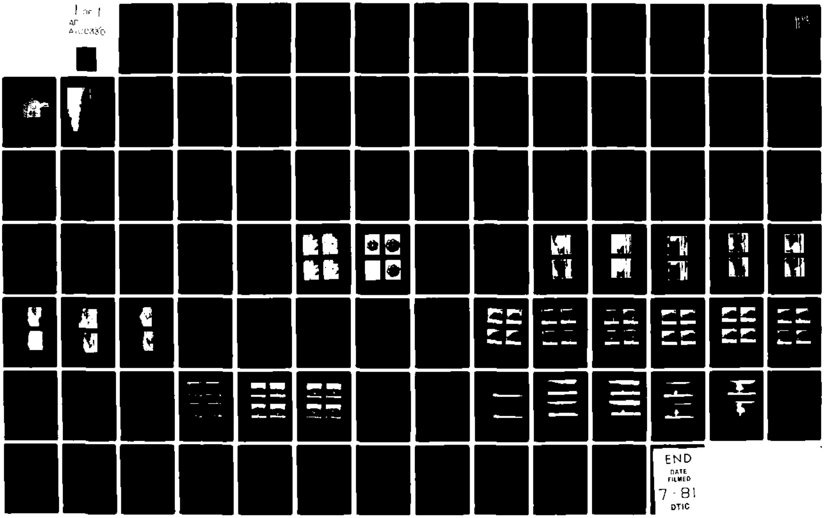

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MISERS BLUFF Series
MISERS BLUFF I and II Technical Photography

University of Denver
Denver Research Institute
P.O. Box 10127
Denver, Colorado 80210

1 October 1980

Final Project Officers Report

CONTRACT No. DNA 001-76-C-0328

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, D. C. 20305

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MISERS BLUFF I Series	High Explosives	Photometric
MISERS BLUFF II Series	TNT	Color Temperature
Ten Events	AN/FO	Shockwave
Technical Photography	Multiple Detonations	Cloud Development
Detonation Phenomena		Charge Composition

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Technical information pertaining to 1/2-ton TNT detonation phenomena from MISERS BLUFF I Series and 118-ton AN/FO detonation phenomena from MISERS BLUFF II Series was obtained photographically and photometrically. The technical information contains data on shockwave separation, surface-surge anomalies, charge composition effects and cloud development and rise.

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SECTION I

INTRODUCTION

1.1 OBJECTIVES

The objectives of this project [illegible] mediate-, and late-time detonation phenomena [illegible] and II (MBI and II) Series using photo[illegible] and to analyze and compare the results [illegible] the series and other prior event [illegible] gurations. The MISERS BLUFF Events [illegible] tions having different charge configurations [illegible] the ground, i.e., height-of-burst (HOB). The photographic [illegible] were obtained on 16 millimeter [illegible] and 35 [illegible] film covering a time period from first-light to 300 seconds [illegible].

The photometric results and the detonation diagnostics from the MBI and II Series have already been presented previously in the *Proceedings of the MISERS BLUFF Symposium*. (Ref. 1)

In addition, the complete photographic documentation of MISERS BLUFF I and II Series is presented in AFWL-TR-79-149 report whose table of contents and list of illustrations are presented in the Appendix Section of this report. (Ref. 2). For the readers edification the Appendix Section also contains a plan view of the MISERS BLUFF II cloud camera layout, Figure 1A, which conforms to Figure 16 in this report. No on-site wind directions were obtained during these events.

1.2 BACKGROUND

The Denver Research Institute (DRI) participated in the Pre

DICE THROW I and II (PDT I and II) Series which were the charge development portion of the effort and the forerunner of the 628-ton AN/FO detonation of the DICE THROW (DT) Events (Refs. 3, 4 and 5). Prior to these series, DRI took part in the events of DISTANT PLAIN, MINE SHAFT and MIDDLE GUST Series and the PRAIRIE FLAT, MIXED COMPANY and Pre-MINE THROW IV Events from which similar photographic records were obtained. These large events afforded the opportunity to assimilate information at expanded spatial and times scales of 10 [1/2 ton, 454 kilogram (kg)], 34 [20 ton (18,144 kg)], 58 [100 ton (90,718 kg)] and 100 [500 ton (453,592 kg)] times the scale from a 1-pound detonation.

The MB I phase was a cratering series of eight events that were conducted to provide the initial input for the development of a multiple ground motion and shock environment predictive model. The instantaneous energy sources for these events were center initiated spherical charges composed of cast trinitrotoluene (TNT), mainly weighing 1000-pounds. The total explosive weight per event ranged from 256 to 24,000 pounds (116 to 10,900 kg) (Ref. 6).

The MB II phase was a cratering series of two events, second of which utilized a charge configuration which was based upon the results obtained from the multiple detonations of MB I (Ref. 7). The instantaneous energy sources for these events were seven-point initiated, hemispherical-ended cylinders (HEC) constructed of individual bags of AN/FO weighing 50 pounds (22.6 kg) each (Ref. 1). The total explosive weight per event ranged from 117 to 707 tons (106,000 to 641,000 kg).

Table 1 presents a list of charge parameters relating to the MB I and II Series. The weights are given in kilograms.

Figures 1, 2 and 3 show charge construction and configurations for certain events in MB I and II.

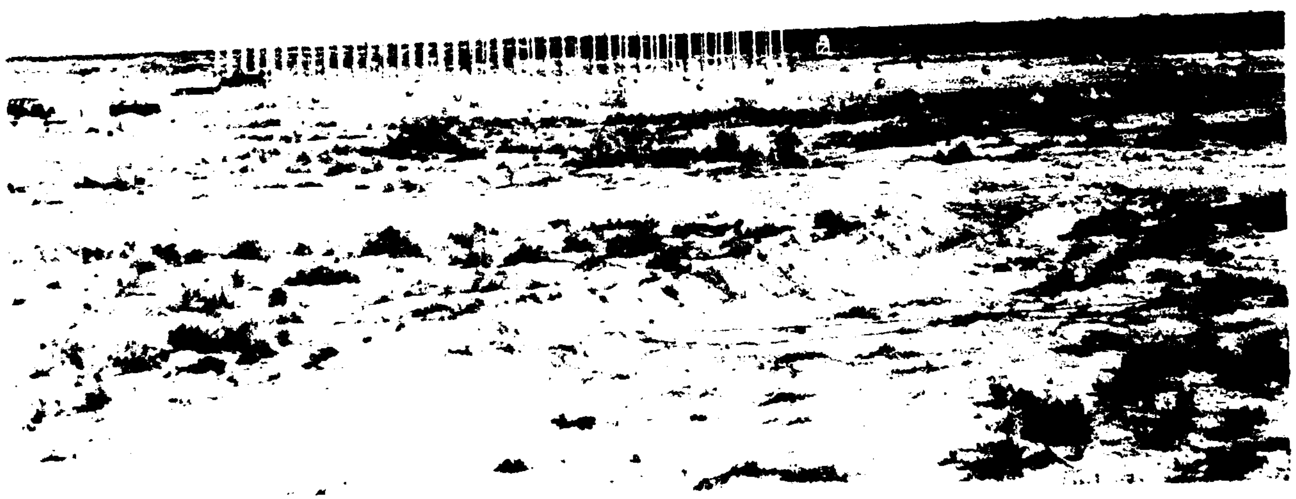


FIGURE 1 CHARGE ARRAY FOR MBI-8 EVENT,
24-1000 LBS. TNT SPHERES.

FIGURE 2 CHARGE CONFIGURATION FOR MBII-1 EVENT, 118-TON AN/FO HEMISPHERICAL-ENDED CYLINDER

FIGURE 3. CHARGE ARRAY FOR MBII-2 EVENT, S.X 118-TON AN/FO HEMISPHERICAL-ENDED CYLINDERS.

TABLE 1. Charge Parameters From MB I and MB II Series

Event	Explosive	Shape	Weight (kg)	Position	Configuration
MBI-1	TNT	Sphere	454	Half-Buried	Single
MBI-2	TNT	Sphere	454	Tangent	Single
MBI-3	TNT	Sphere	454	Half-Buried	Single
MBI-4	TNT	Sphere	6-454	Tangent	Hexagon
MBI-5	TNT	Sphere	454	Full-Buried	Single
MBI-6	TNT	Sphere	6-454	Half-Buried	Hexagon
MBI-7	TNT	Sphere	116	Half-Buried	Single
MBI-8	TNT	Sphere	24-454	Tangent	Multiple Hexagons
MBII-1	AN/FO	HEC	106,000	Tangent	Single
MBII-2	AN/FO	HEC	6-107,000	Tangent	Hexagon

SECTION II

PROCEDURE

2.1 EXPERIMENTAL SETUP

The MISERS BLUFF test series was comprised of two phases. Phase I was conducted at the White Sands Missile Range (WSMR), New Mexico and consisted of a cratering series of eight events. Three out of the eight events (4, 6 and 8) were multiple detonations made up of hexagonal arrays (Events 4 and 6) and a 24 unit array constructed of seven hexagonal sections (Event 8). The charges were in either tangent, half- or full-buried configurations. The geology for Phase I consisted of a level area that had a 7- to 8-foot (ft), 2.12- to 2.44-meter(m) deep water table, with little or no caliche present. Based upon extensive auger drilling, a test bed of the required size was selected on the Queen 15 site of the WSMR facility (Ref. 9).

Phase II was conducted at Planet Ranch in Arizona and consisted of two events. The first event was a single 117-ton (106,000 kg) AN/FO detonation; whereas, the second event was made up of a hexagonal array of 707 tons (641,000 kg) of AN/FO. The test bed was in a relatively dry river basin whose geology consists mainly of deposited sand and gravel with a water table, at the time of the experiments, generally below the predicted crater depth (Ref. 9). Figures 4 and 5 present plan views of the multiple arrays and relative positions of the close-in cameras in MB I and II Series.

2.2 INSTRUMENTATION AND FIELD OPERATION

The basic technical photographic coverage of the detonation phenomena from the MISERS BLUFF Phases I and II were made from ground

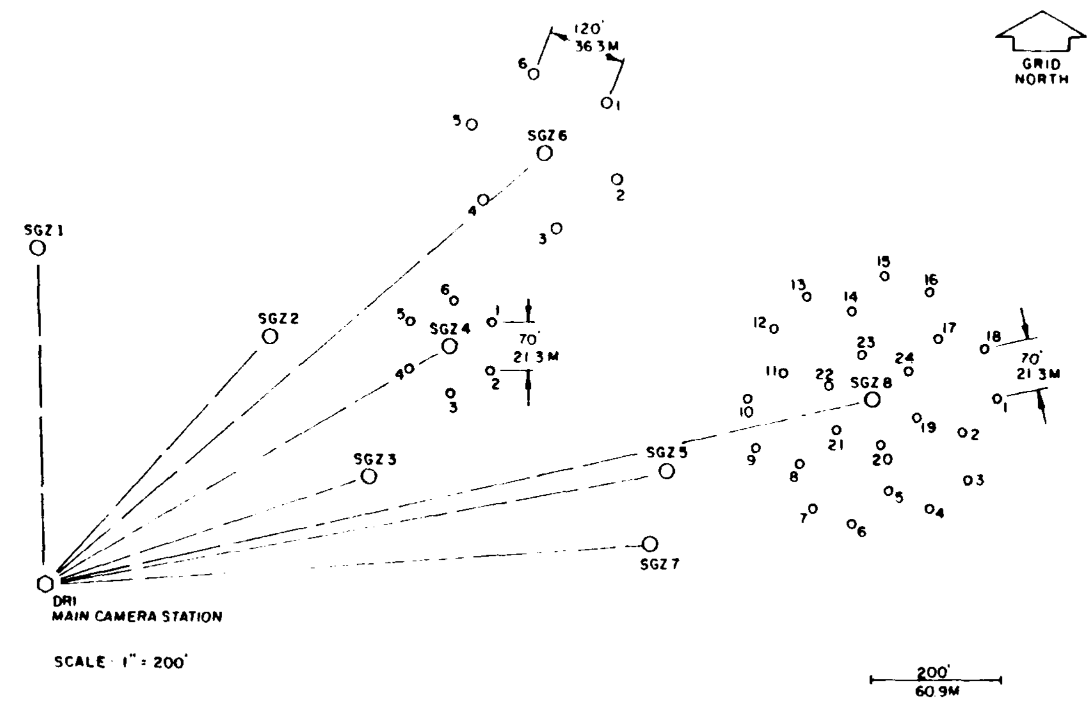


FIGURE 4. PLAN VIEW OF THE MISERS BLUFF I SITE LAYOUT

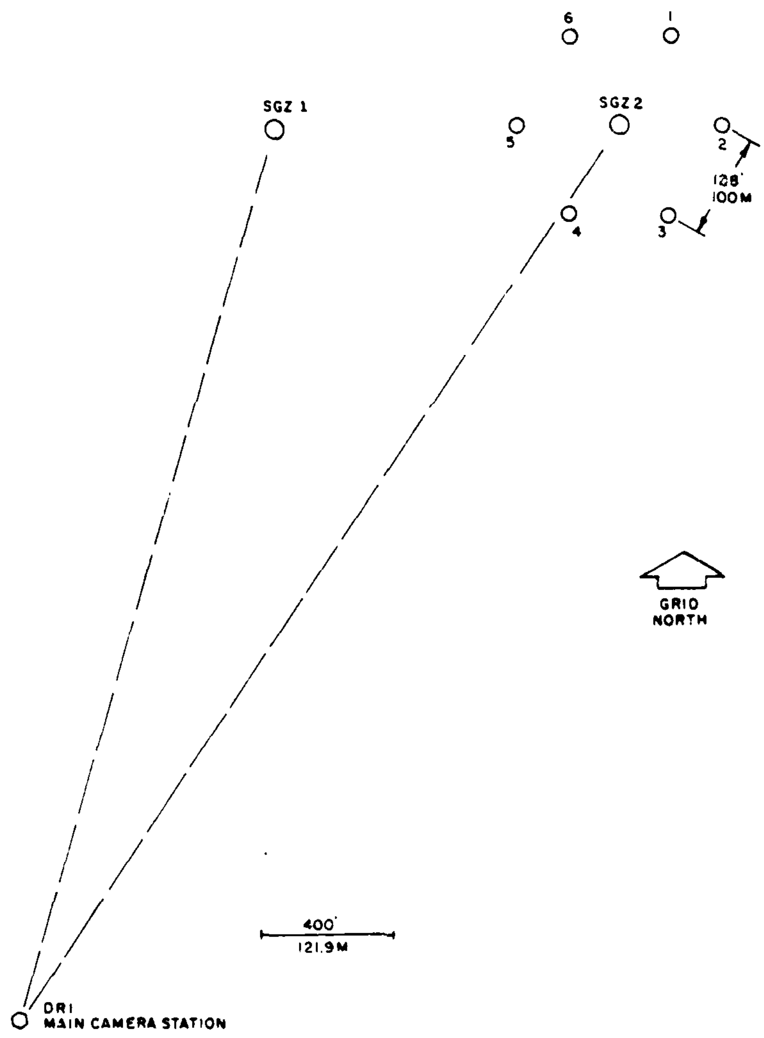


FIGURE 5. PLAN VIEW OF THE MISERS BLUFF II SITE LAYOUT

level and aerial stations. The ground level stations varied in number and position from event to event depending upon whether the detonations were singular or multiple. The altitude of the aerial station, which recorded only the multiple bursts in MB I phase and both of the bursts in MB II phase, changed with the variations in the strength of the detonations.

2.2.1 Instrumentation and Field Operation for MB I

The technical photography for the events of MB I was furnished by DRI, WSMR and the Williamson Aircraft Company (WAC). DRI provided the technical supervision for the photographic effort in addition to supplying high-speed cameras [26,000 frames per second (fr/s)], photoelectric (photometric) devices and electronic recording equipment.

WSMR provided high-speed photography from ground stations at framing rates up to 5000 fr/s to record fireball development and interaction, surface surge, shockwave propogation, and cloud development and rise. The aerial coverage of the multiple detonations before, during and after the events was performed by WAC using high-speed, stereo* and still cameras.

Most of the ground-level cameras for the singular and multiple bursts for MB I were located at one main camera station situated approximately south of surface ground zero (SGZ) at distances which ranged from about 500 ft (152m) to 1400 ft (427m). The cloud development and rise for all the events were photographed from two remote ground stations located at about 6,000 ft (1829m) to 9,000 ft (2743m) from SGZ at

*Camera, film and support supplied by U.S. Geological Survey, Flagstaff, Arizona, courtesy D.J. Roddy.

an angle of about 70 degrees (70°) from each other. The multiple events were photographically and photometrically covered by DRI from three ground stations for MISERS BLUFF I, Events 4 and 6 (MB I-4 and MB I-6) and from five other locations for MISERS BLUFF I, Event 8 (MB I-8). Tables 2 through 9 present a list of ground surface cameras used during the MB I Events. Table 10 lists aerial cameras employed during the multiple events of MB I.

In the listings presented in Tables 2 through 9, the remote stationed 70mm Photosonic 10R cameras, used to document the cloud, were actually located closer to the north and west than as indicated to the northwest and southwest of SGZ, respectively. Station position names of northwest and southwest will be used throughout this report in order not to confuse already published information on these camera coverages.

The lens values in these tables are given in millimeters (mm) and their apertures in f-stop numbers. The nominal framing rates are presented in frames per second (fr/s). The Hycan and Nova framing rates ranged from about 4500 to 5500 fr/s. Their exposure times in seconds (s) were equal to [(1/2.5)x(fr/s)]s. The Photosonic 10A framing rate was 20 fr/s with an exposure of (1/3600)s, i.e., 2 degree (2°) shutter. The Photosonic 10R framing rate was 6 fr/s with an exposure of (1/1080) s, i.e., 2° shutter. The ground station DB Milliken cameras were operated at 400 or 300 fr/s with shutter settings of 36° which gave exposure times of (1/3600)s and (1/3000)s, respectively. The Dynafax cameras gave exposures of less than 1 microsecond (μs) at 26,000 fr/s.

The aerial DB Milliken cameras were operated with different shutter openings depending on the cameras framing rates and the films

TABLE 2. Camera Coverage For MBI-1, 8/2/77
Distance From Main Camera Station
503 Ft (153 M)

Position	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam[1]	50	11.0	5000	IR[2]	SGZ
Main	Nova	50	2.8	5000	EF	SGZ-100' Right
Main	Nova	50	2.8	5000	EF	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Right
Main	Photosonic 10A[3]	150	8.0	20	SB	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ - ± 100'
Main	DB Milliken	25	4.0	400	EF	SGZ
Main	Photosonic 10A	150	8.0	20	SB	SGZ' - 100' Left
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Left
NW	Photosonic 10R[4]	100	22.0	6	SB	Cloud
SW	Photosonic 10R[4]	150	22.0	6	SB	Cloud

[1] DRI Hycam
[2] Wratten 12 Filter for this and all succeeding events
[3] Lost, No 2° Shutter position existed
[4] No tracking, cloud coverage limited to 2 min

TABLE 3. Camera Coverage For MBI-2, 8/15/77
Distance From Main Camera Station
509 Ft (155 M)

Position	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam[1]	25	8.0	5000	IR	SGZ
Main	Nova	50	2.0	5000	EF	SGZ - 100' Right
Main	Nova	50	2.0	5000	EF	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Right
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ ± 100'
Main	DB Milliken	25	4.0	400	EF	SGZ
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Left
Main	Photosonic 10A	150	8.0	20	SB	100' - 200 Left
NW	Photosonic 10R[2]	100	22.0	6	SB	Cloud
SW	Photosonic 10R[2]	150	22.0	6	SB	Cloud

[1] DRI Hycam, Lost record, Camera jammed
[2] Horizontal tracking 5 min., total recording the same for this and all succeeding events

TABLE 4. Camera Coverage For MBI-3, 8/23/77 Distance From Main Camera Station 516 Ft (157 M)

Position	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main[1]	Hycam[2]	25	8.0	5000	IR	SGZ
Main	Nova	50	2.0	5000	EF	SGZ - 100' Right
Main	Nova	50	2.0	5000	EF	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Right
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ ± 100'
Main	DE Milliken	25	4.0	400	EF	SGZ
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Left
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Left
NW	Photosonic 10R	100	22.0	6	SB	Cloud
SW	Photosonic 10R	150	22.0	6	SB	Cloud

[1] Main Camera Station Rotated clockwise 30° for this and all succeeding events

[2] DRI Camera, all succeeding events used WSMR Hycam

TABLE 5. Camera Coverage For MBI-4, 9/7/77 Distance From Main 713 Ft (217 M) and 30° Camera Stations

Position	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam	25	8.0	5000	IR	SGZ, Charges 4 & 1
Main	Nova	50	2.0	5000	EF	Charges 3(2) - 100' Right
Main	Nova	50	2.0	5000	EF	Charges 3(2), 100'-200' Right
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Right
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Right
Main	Photosonic 10A	80	5.6	20	MS	SGZ + 100'
Main	DB Milliken	13	4.0	400	EF	SGZ, Charges 4(1)
Main	Photosonic 10A	150	8.0	20	SB	SGZ - 100' Left
Main	Photosonic 10A	150	8.0	20	SB	100' - 200' Left
NW	Photosonic 10R	100	22.0	6	SB	Cloud
SW	Photosonic 10R	100	22.0	6	SB	Cloud
Main	Nova	50	2.0	5000	EF	Charges 5(6) - 100' Left
Main	Nova	50	2.0	5000	EF	Charges 5(6), 100'-200' Left
30	DB Milliken	13	4.0	400	EF	SGZ
DRI	Dynafax	50	11.0	26000	SB	Charges (4,5,3,2)
DRI	Dynafax	75	11.0	26000	SB	Charges (5,6,2,1)
DRI	Dynafax	50	11.0	26000	SB	Charges (1,2,6,5)
DRI	Dynafax	75	11.0	26000	SB	Charges (2,3,5,4)
30	Nova	50	2.0	5000	EF	SGZ, Charges (4) & (3)
30	Nova	50	2.0	5000	EF	Charge 2- 100' Right

Soft focus
Poor focus
Shutter at 7.5 (overexposure) instead of 2
NW camera moved further from SGZ, same for all succeeding events
Poor focus

TABLE 6. Camera Coverage For MBI-5, 9/22/77 Distance
From Main Camera Station 909 Ft (277 M)

Position	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam	50	8.0	5000	IR	SGZ
Main	Nova	100	2.8	5000	EF	SGZ - 75' Right
Main	Nova	100	2.8	5000	EF	SGZ - 75' Left
Main	Photosonic 10A	250	8.0	20	SB	SGZ - 75' Right
Main	Photosonic 10A	250	8.0	20	SB	75' - 200' Right
Main	Photosonic 10A	150	5.6	20	MS	SGZ ± 75'
Main	DB Milliken	25	4.0	400	EF	SGZ
Main	Photosonic 10A	250	8.0	20	SB	SGZ - 75' Left
Main	Photosonic 10A	250	8.0	20	SB	75' - 200' Left
NW	Photosonic 10B	100	22.0	6	SB	Cloud
SW	Photosonic 10B	100	22.0	6	SB	Cloud
20 psi	DB Milliken	25	5.6	300	EF	Debris Targets
10 psi	DB Milliken	25	5.6	300	EF	Debris Targets
5 psi	DB Milliken	50	5.6	300	EF	Targets - SGZ

[illegible] Focus

TABLE 7. Camera Coverage For MBI-6, 10/13/77 Distance From Main and 30° Camera Stations 1004 Ft (306 M)

Station	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam	50	8.0	5000	IR	SGZ, Chgs 4(1)
Main	Nova	150	3.8	5000	EF	Chgs 3(2), 40'-100' Right
Main	Nova	75	2.0	5000	EF	Chgs 3(2), 100'-200'Right
Main	Photosonic 10A	250	8.0	20	SB	SGZ - 100' Right
Main	Photosonic 10A	250	8.0	20	SB	100'-200' Right
Main	Photosonic 10A	100	5.6	20	MS	SGZ ± 100'
Main	DB Milliken	13	4.0	400	EF	SGZ, Chgs 4(1)
Main	Photosonic 10A	250	8.0	20	SB	SGZ - 100' Left
Main	Photosonic 10A	250	8.0	20	SB	100' - 200'Left
NW	Photosonic 10R	100	22.0	6	SB	Cloud
SW	Photosonic 10R	100	22.0	6	SB	Cloud
Main	Nova	75	2.0	5000	EF	Chgs 5(6), 40'-100' Left
Main	Nova	75	2.0	5000	EF	Chgs 5(6), 100'-200' Left
30	DB Milliken	13	4.0	400	EF	SGZ
DRI	Dynafax	50	11.0	26000	SB	Chgs 1, 2, 6
DRI	Dynafax	50	11.0	26000	SB	Chgs 3, 4, 5
DRI	Dynafax	50	11.0	26000	SB	Chgs 3, 4, 5
DRI	Dynafax	50	11.0	26000	SB	Chgs 1, 2, 6
30	Nova	150	3.8	5000	EF	Chgs (3) & (4)
30	Nova	75	2.0	5000	EF	Chg 2 -100' Right
20 psi	DB Milliken	13	5.6	300	EF	Debris Targets
10 psi	DB Milliken	13	5.6	300	EF	Debris Targets
5 psi	DB Milliken	50	5.6	300	EF	Targets - SGZ

Poor Focus

TABLE 8. Camera Coverage For MBI-7, 10/26/77 Distance From Main Camera Station 915 Ft (279 M)

Station	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Hycam	100	8.0	5000	IR	SGZ
Main	Nova	150	3.8	5000	EF	SGZ - 50' Right
Main	Nova	150	3.8	5000	EF	50' - 100' Right
Main	Photosonic 10A	500	8.0	20	SB	SGZ - 50' Right
Main	Photosonic 10A	500	8.0	20	SB	50' - 100' Right
Main	Photosonic 10A	250	5.6	20	MS	SGZ ± 50'
Main	DB Milliken	50	4.0	400	EF	SGZ
Main	Photosonic 10A	500	8.0	20	SB	SGZ - 50' Left
Main	Photosonic 10A	500	8.0	20	SB	50' - 100' Left
NW	Photosonic 10R	150	22.0	6	SB	Cloud
SW	Photosonic 10R	150	22.0	6	SB	Cloud
20 psi	DB Milliken	13	5.6	300	EF	Debris Targets
10 psi	DB Milliken	13	5.6	300	EF	Debris Targets
5 psi	DB Milliken	50	5.6	300	EF	Targets - SGZ

TABLE 9. Camera Coverage For MBI-8 12/7/77 Distance From Main Camera Station 1413 Ft (431 M)

Station	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film	View
Main	Nova	25	8.0	5000	IR	SGZ, Chgs 9 & 10
Main	Nova	150	3.8	5000	EF	Chg 14 - 80' Left
Main	Nova	150	3.8	5000	EF	Chg 14, 80' - 160' Left
Main	Photosonic 10A	150	8.0	20	SB	Chg 14-80' Left
Main	Photosonic 10A	150	8.0	20	SB	Chg 14, 80' - 160' Left
Main	Photosonic 10A	105	5.6	20	MS	SGZ $\pm$ 150'
Main	DB Milliken	13	4.0	400	EF	SGZ
Main	Photosonic 10A	150	8.0	20	SB	Chg 5 - 80' Right
Main	Photosonic 10A	150	8.0	20	SB	Chg 5, 80' - 240' Right
NW	Photosonic 10R	100	22.0	6	SB	Cloud
SW	Photosonic 10R	100	22.0	6	SB	Cloud
Main	Novas	150	3.8	5000	EF	Chg 14 - 160' - 240' Left
Main	Novas	150	3.8	5000	EF	Chg 14, 240' - 320' Left
DRI	Dynafax	50	11.0	26000	SB	Chgs 9-14
DRI	Dynafax	50	11.0	26000	SB	Chgs 13-18
DRI	Dynafax	50	11.0	26000	SB	Chgs 18-15
DRI	Dynafax	50	11.0	26000	SB	Chgs 4-9
30	Novas	150	3.8	5000	EF	Chgs 12(13) - 240' Left
30	Novas	150	3.8	5000	EF	Chgs 12(13), 120' - 360' Left
10 psi	DB Milliken	25	5.6	300	EF	Jeep Target
10 psi	DB Milliken	25	5.6	300	EF	Jeep Target
20 psi	DB Milliken	13	5.6	300	EF	Debris Targets
10 psi	DB Milliken	13	5.6	300	EF	Debris Targets
5 psi	DB Milliken	50	5.6	300	EF	Target - SGZ

TABLE 10. Aerial Coverage For MBI-4, 6 and 8

Number	Camera	Lens (mm) MBI-4	Lens (mm) MBI-6	Lens (mm) MBI-8	Aperture	Framing Rate (fr/s)	Film
1	DB Milliken	25	50	100	6.3	400	EF
2	DB Milliken	50	75	75	5.6	400	IR
3	DB Milliken	12	12	12	8.0	24	MS
4	DB Milliken	50	50	150	6.3	400	EF
5	Hulcher	380	380	380	4.5	22	Aero
6	Hulcher	380	380	380	5.6	22	SB
7	Fastax	50	75	152	2.0	2000	EF
8	Nikon	28	28	28	---	6/min	EK64

Includes B&W still and stereo photography
36 shutter
4 shutter
12 shutter
1/2330 s
1/2.5 x (fr/s)s, Missed MBI-4
MBI-4, 2000 fr/s; MBI-6 & -8, 3000 fr/s

that were used. The Fastax camera exposure was equal to [(1/2.5) x (fr/s)]s. All cameras recorded on 16mm formats except for the Photosonic cameras which recorded on 70mm formats.

The films utilized by the cameras listed in these tables were 2241, Ektachrome EF (EF); IE 449, Ektachrome IR (IR); 7256, Ektachrome MS (MS); 2476, Linagraph Shellburst (SB) and 2445, Aerocolor Negative (Aero). The Nikon camera employed Ektachrome 64 (EK 64) film.

2.2.2 Instrumentation and Field Operation From MB II

The technical photography for the two events of MB II was furnished by DRI, WAC, and USGS. DRI provided the ground level coverage while WAC and USGS provided aerial coverage. Besides the technical photography, DRI supplied test-bed photography of military hardware and structures for both events. These cameras were situated in the 100 to 2 pounds per square inch (psi), 689 to 13.7 kilopascals (kPa) pressure region. Tables 11, 12 and 13 present a list of cameras employed during the MB II events.

Most of the lenses' sizes and aperature settings and cameras' framing rates and exposure times listed in Tables 11, 12 and 13 are similar to those presented in the previous tables for the MB I Events. The only differences are in the type of cameras utilized during the MB II Events. The Fastax camera framing rate ranged from 4500 to 5500 with an exposure time of [(1/2.5) x (fr/s)]s. The Hulcher cameras had 70mm formats and were operated at an exposure time of (1/2880)s. The Locam utilized a 36 shutter settings as did all the DB Millikens operating at 400 fr/s. The DB Millikens operating at 250 fr/s employed an 18 shutter setting.

TABLE 11. Camera Coverage For MBII-1, 6/28/78, Distance From Main Camera Station 2918 Ft (889M)

Station	Camera	Lens	Aperture	Framing Rate	Film	View
Main	Hycam	50	8.0	5000	IR	SGZ
Main	Fastax	100	3.5	5000	EF	SGZ - 500' Right
Main	Fastax	100	3.5	5000	EF	500' - 1000' Right
Main	Fastax	100	3.5	5000	EF	SGZ - 500' Left
Main	Fastax	100	3.5	5000	EF	500' - 1000' Left
Main	Locam[1]	10	8.0	100	EF	SGZ - Cloud
Main	DB Milliken	12.5	4.0	400	EF	SGZ - Cloud
Main	Hulcher	150	4.5	20	Aero	SGZ
Main	Hulcher	240	4.5	20	SB	SGZ - 500' Right
Main	Hulcher[2]	240	4.5	20	SB	500' Right-1000'RT
Main	Hulcher	240	4.5	20	SB	SGZ - 500' Left
Main	Hulcher	240	4.5	20	SB	500' Left-1000' LT
Main	Dynafax	250	32.0	26000	SB	SGZ
A(225°)	Dynafax	150	32.0	26000	SB	SGZ
B(345°)	Dynafax	100	32.0	26000	SB	SGZ
C(105°)	Dynafax	100	32.0	26000	SB	SGZ
S	Hulcher	150	4.5	10	SB	Cloud
N	Hulcher	150	4.5	10	SB	Cloud
Adm.	Hulcher	150	4.5	10	SB	Cloud
D-1	Fastax Streak	1250	16.0	--[9]	2498	Charge
D-2	Fastax Streak	1250	16.0	--[9]	2498	Charge
50 psi	DB Milliken	12.5	4.0	250	EF	Ejecta
20 psi	DB Milliken	12.5	4.0	250	EF	Ejecta
20 psi	DB Milliken	12.5	4.0	250	EF	Ejecta
10 psi[10]	DB Milliken	12.5	4.0	250	EF	Ejecta
5 psi	DB Milliken	12.5	4.0	250	EF	Ejecta overall

Underexposed - 400 fr/s
Out-of-focus
Out-of-synchronization
1500 Ft (457 M)
5500 Ft (1676 M) from SGZ
Assumed 18,000 Ft (5488 M) from SGZ (Topographic Map Measurement)
14,632 Ft (4461 M) from SGZ
Diagnostics 1840 Ft (561 M)
40 mm/ms
Test Bed Cameras

TABLE 12. Camera Coverage for MBII-2, 8/30/78
Distance from Main Camera Station 3359 Ft (1024M)

Station	Camera	Lens	Aperture	Framing Rate	Film	View
Main	Hycam	25	8.0	5000	IR	SGZ
Main	Fastax	100	3.5	5000	EF	Chgs 5(6)-250' LT
Main	Fastax	100	3.5	5000	EF	250'-500' LT
Main	Fastax	100	3.5	5000	EF	500'-750' LT
Main	Fastax	100	3.5	5000	EF	750'-1000' LT
Main	Locam	10	5.6	100	EF	SGZ-Cloud
Main	DB Milliken	16	5.6	400	EF	SGZ-Cloud
Main	Hulcher	150	4.5	20	Aero	SGZ
Main	Hulcher	240	5.6	20	SB	Chgs 5(6)-500' LT
Main	Hulcher	240	5.6	20	SB	500'-1000' LT
Main	Hulcher	240	5.6	20	SB	Chgs 3(2)-500' RT
Main	Hulcher	240	5.6	20	SB	500'-1000' RT
M-2[1]	Fastax	25	2.3	5000	EF	SGZ-Chgs 3 & 4
M-2[1]	Fastax	35	2.0	5000	EF	SGZ-Chgs 3 & 4
M-2[1]	DB Milliken	12.5	4.0	400	EF	SGZ-Chgs 3 & 4
AA[2]	Hulcher	150	5.6	20	SB	Chgs 4(3)-RT
BB[3]	Hulcher	75	5.6	20	SB	SGZ-Chgs 2 & 5
CC[4]	Hulcher	150	5.6	20	SB	Chgs 6(1)-LT
AA	Dynafax	150	32.0	26000	SB	Chgs 3 & 4
BB	Dynafax[5]	100	32.0	26000	SB	Chgs 2 & 5
CC	Dynafax[6]	100	32.0	26000	SB	Chgs 1 & 6
AA	DB Milliken	12.5	4.0	250	EF	SGZ-Chgs 2 & 5
BB	DB Milliken	12.5	5.6	400	EF	SGZ-Chgs 2 & 5
CC	DB Milliken	50	4.0	250	EF	Mountain behind Chg 6
D-1[7]	Fastax Streak	1250	11.0	--[16]	2498	Chgs 6 & 1
D-2[8]	Fastax Streak[9]	1250	11.0	--[16]	2498	Chgs 4 & 5
D-3[8]	Fastax Streak	1250	11.0	--[16]	2498	Chgs 2 & 3
S[10]	DB Milliken	25	4.0	250	EF	SGZ-Cloud
S[10]	DB Milliken[11]	100	4.0	250	EF	Mountain above Chg 1
S[10]	Hulcher	150	5.6	0.5	SB	Cloud
N[12]	Hulcher	150	5.6	0.5	SB	Cloud
Adm.[13]	Hulcher	150	5.6	0.5	SB	Cloud
100 Psi	DB Milliken[14]	12.5	4.0	250	EF	Ejecta-Pad
50 Psi	DB Milliken[15]	12.5	4.0	250	EF	Ejecta-Target
20 Psi	DB Milliken	12.5	4.0	250	EF	Ejecta-Target
10 Psi	DB Milliken	12.5	4.0	250	EF	Ejecta-Target
5 Psi	DB Milliken	50	4.0	250	EF	Ejecta-Overall

[1] M-2 - 2200 Ft (670 M) from SGZ on a line halfway between Charges 3 and 4
[2] AA - 1702 Ft (519 M) from SGZ
[3] BB - 1666 Ft (508 M) from SGZ
[4] CC - 1677 Ft (511 M) from SGZ
[5] Lost shutter problems - no data
[6] Lost movement off SGZ - no data
[7] D-1 - 2394 Ft (730 M) from SGZ
[8] D-2 and D-3 - 2373 Ft (723 M) from SGZ
[9] Late Trigger - slow speed - lost data
[10] S - 4500 Ft (1372 M) from SGZ
[11] Camera jammed - lost data
[12] N - Assumed 18,000 Ft (5488 M) from SGZ
[13] Adm - 15,635 Ft (4767 M)
[14] Camera damaged - no data
[15] Camera damaged - no data
[16] 40 [illegible]

TABLE 13. Aerial Coverage For MBII-1 and 2

Number	Camera	Lens (mm)	Aperture	Framing Rate (fr/s)	Film
1	DB Milliken	50	6.3	400	EF
2	DB Milliken	75	5.6	400	IR
3	DB Milliken	12	8.0	24	MS
4	DB Milliken	75	6.3	400	VNX
5	Hulcher	380	8.0	23	Aero
6	Fastax	150	2.0	3000	EF
7	Nikon	28	---	6/min	EK64

Includes B&W and color still and stereo photography
20 shutter
40 shutter
10 shutter
18 shutter
1/2880 s
Ektachrome 200 for MBII-1
1/2.5 x (fr/s)s, Late trigger MBII-1; Late, late trigger MBII-2

SECTION III

RESULTS AND DISCUSSION

The data presented in this report are based on information obtained from photographic and some photometric records. The output parameters associated with the MB I and II Series are presented in the following paragraphs in a sequence which was indicative of the detonation process, i.e., from initiation to cloud development and rise independent of the charge diagnostics data already presented in the previously mentioned report (Ref. 1).

3.1 PHOTOMETRIC CHARACTERIZATION OF THE MB II-2, CHARGE 5 COMPOSITION

Since the presentation of the detonation diagnostics from MISERS BLUFF I and II Series, there has been some recent data generated based on the AN/FO composition which may have had a direct effect upon the blastwave output characteristics. The fundamental reason for analyzing the AN/FO compositions was that there were apparent problems associated with the MB II AN/FO detonations (Ref. 1), which can be wholly or partially attributed to the charge composition when compared to the detonation characteristics from PDT II-2 and DT. Photometric recordings of the color temperature from Charge 5 of MB II-2 Event was about 25 low. The overall peak light output from all six charges was only 12 of the average of PDT II-2 and DT Events (Refs. 1 and 4).

An effort was made to determine the relationship of charge composition, i.e., the relative ammonium nitrate (AN) prill surface area and fuel oil (FO) percentage, to its fireball color temperature and photometric characteristics ("fingerprints") for the charge materials used in the MISERS BLUFF II Events. Since MISERS BLUFF I Series consisted of spherical TNT detonations no analysis were made on the charges other than their initiation times which were covered in the diagnostics report. (Ref. 1).

Two of the most outstanding physical differences between the AN/FO Events of DICE THROW and MISERS BLUFF were in the average FO percentage and the percentage of AN particle-size distribution. The MB II AN particle-size distribution was skewed toward the fine particles (Refs. 10 and 11). An increase in fine particles will increase the total particle-surface areas for a fixed weight of explosive. Since an optimum FO coating is required, nominally 6 percent, No. 2 diesel fuel, an increase in AN surface areas is expected to cause an increase in the total requirement of fuel oil in order to maintain an optimum surface coating. In reality, the MB II charges not only were high in fine AN particles but low in FO.

If the AN/FO composition is considered to be similar to that in a concrete mix, where the fineness of the aggregates is controlled within limits for a specific strength of concrete desired so that each particle is coated with the cohesive material (cement and water) in a specified amount, a fineness modulus (FM) can be incorporated in a similar manner to an AN/FO mixture.

In concrete mixtures (Ref. 12), a measure of acceptable surface areas of the aggregate (sand, gravel and stone) is made by using a fineness modulus (FM) number which is based on sieve size numbers (see Table 14 from Ref. 12). As example, the sand FM of 3.70 was obtained by adding the retained percentage ([illegible]) of a sieve to the succeeding sieves and dividing by 100, i.e., No. 4, 20 percent; No. 8, 15 percent; No. 16, 20 percent; No. 30, 15 percent; No. 50, 20 percent; and No. 100, 10 percent. In an acceptable concrete mixture, the percentage retained by the sieve can vary to a degree whereby the FM values fall within a certain range. The variation in the above example can be made in the retained percentage for the different sieve sizes whereby the FM of 3.70 would be the same. As an example, of 4, 25 percent; No. 8, 10 percent; No. 16, 15 percent; No. 30, 25 percent; No. 50, 10 percent; No. 100, 15 percent also give an FM of 3.70. If the particles geometry is considered to be in a spherical or cubical form, in this example, the total surface areas of the two particle-size mixtures would be the same for the above two sand samples.

TABLE 14. Typical Sieve Analysis of Sand (Ref. 12)

Aggregate	100	50	30	16	8	4	Fineness Modulus	Range Size
Sand	100	90	70	55	35	20	3.70	0-3/8
	10	20	15	20	15	20	-	
Sand	100	85	65	40	20	0	3.10	0-4
	15	20	25	20	20	0	-	
Sand	95	75	60	30	0	0	2.60	0-8
	20	15	30	30	0	0	-	

Based on the assumption the total presented area of the AN is a major contributor to FO percentage in an ideal mixture, it is proposed that FM values be used for any specified sieve numbers in the analysis of the AN particles. Variations away from the ideal mixture (based on FM per percentage of FO) are expected to have an effect on peak pressure, I-value, average detonation velocity, fireball color temperature and fingerprint characteristics, i.e., AN/FO detonation parameters.

Based on Messrs. Swisdak and Peckham's analysis of the average AN particle-size distributions for PDT II-2, DT and MB II, tabulations were made of the FM and presented area factor (AF) for the AN particles within the charges which are presented in Tables 15 and 16, respectively.

TABLE 15. FM Tabulations for AN Particles from PDT II-2, DT and MB II-2 Charge 5

Event	Sieve Size								FM
	Pan	35	20	16	14	12	10	6	
PDT II-2	100	99	98	94	88	72	6	0	5.57
	1	1	4	6	16	66	6	0	--
DT	100	99	98	95	87	62	25	0	5.66
	1	1	3	8	25	37	25	0	--
MB II-2 chg. 5	100	99	92	72	56	32	11	0	4.62
	1	7	20	16	24	21	11	0	--

TABLE 16. AF Tabulations for PDT II-2, DT, and MB II-2, Charge 5

Event	Sieve Size						AF
	35	20	16	14	12	10	
PDT II-2	35	80	96	224	792	60	1.24
	1	4	6	16	66	6	--
DT	35	60	128	350	420	250	1.29
	1	3	8	25	37	25	--
MB II-2 chg. 5	245	400	256	336	252	110	1.60
	7	20	16	24	21	11	--

Notice the amount of surface area contribution by the high number sieve (small openings) for the MB 11-2, chg. 5, as compared to the PDT 11-2 and DT AN/FO charges.

The presented area factor (AF) based on assumed spherical or cubical *geometries* and on percentage retained (excluding pan) is, as it should be, very nearly inversely proportional to the FM. The AF numbers were obtained by adding the numbers derived by multiplying the sieve number by the retained percentage and dividing by 100. Table 17 presents the AN and AF ratios numbers based on Messrs. Swisdak and Peckham's AN/FO data.

TABLE 17. AN and AF Ratios for PDT 11-2, DT and MB 11-2, Charge 5

Event	FM	FM Ratio[1]	AF	AF Ratio[2]
PDT 11-2	5.57	1.21	1.24	1.29
DT	5.66	1.23	1.29	1.24
MB 11-2, chg. 5	4.62	1.00	1.60	1.00

[1]FM Ratios: (PDT 11-2)/(MB 11-2, chg. 5) and (DT)/(MB 11-2, Chg. 5)
[2]AF Ratios: (MB 11-2, chg. 5)/(PDT 11-2) and (MB 11-2, chg. 5)/(DT)

Note that comparison of MB 11-2, chg. 5 to PDT 11-2 and DT indicate a 24 to 29 percent (27 average) increase in presented area for the MB 11-2, chg. 5. Note how close the FM and AF ratios compare in value.

Based on Messrs. Swisdak and Peckham, the average FM values for the above events are as follows:

PDT 11-2	6.0 ± 0.4
DT	6.1 ± 0.4
MB 11-2, chg. 5	5.3 ± 1.2

If a consideration of 0.7 percent FO reduction for MB II-2, chg. 5 based on an ideal amount of 6 percent [(0.7/6)100 = 11.7%)] coupled with an average increase of 27 percent in AN area, (over the average) indicated for PDT II-2 and DT, would present a major AN surface coating problem. This condition could have been accentuated further in certain regions of the AN/FO charge for MB II-2, chg. 5 if the deviation of -1.2 percent was considered [(0.7 + 1.2)(100)/6 = 31.7] coupled with the 27 percent increase in AN area which could have produced very little or no FO coating of the AN prills in the major portions of the MB II-2, charge 5.

Photographic and photometric results obtained by DRI, Ref. 1, indicate that the average fireball surface color temperature of MB II-2, chg. 5 was only 5570°K whereas the DT charge gave an average fireball surface color temperature of 7030°K. If the emissivity of the two charges were considered to be the same, then, by the Stefan-Boltzman law where the peak intensity output of the source varies as the fourth power of their temperatures, their ratio would give a value of 2.54 which is only 39 percent of the DT peak intensity. Actually, the MB II-2, chg. 5 produced a higher intensity than the average of all six charges in MB II-2 whose total peak output was only 12 percent of the expected value based on DT and PDT II-2 scaled values (Ref. 1).

Recently DRI developed a procedure of phase relating two photometric signals obtained from a number of events. One is based on broadband unit light radiation (ULR) signal and the other on narrowband ULR signal. The sensors for the two ULR devices were of the same material, except that one received all the color radiation it was capable of sensing and the other received only *narrow-band* radiation in the red region (peak at 725 nm). The results from four different charges using phase relationships (lissajous patterns) are presented in Figure 6. The utilization of ULR signals removes the effect of the device distances and the effect of geometric expansion of the charges, i.e., *spherical versus cylindrical*.

The major differences in the patterns (fingerprints) for both AN/FO detonations can be attributed to the differences in the composition of AN prill particle-size distribution and FO percentages. The difference in the 8-pound Pentolite (50 percent PETN and 50 percent TNT) and 100-ton TNT patterns can be attributed to the better oxygen balance in Pentolite. It is known that TNT has much more after-burn characteristics than Pentolite. This effect could contribute to the slower rise in the red-band and longer contribution afterwards. This after-burn characteristic can be the cause of the unusual fingerprints for the TNT and MB II-2, charge 5. Note that [illegible] and [illegible] Pentolite have similar signatures.

3.2 COMPARISON OF AN/FO COMPOSITION FROM ALL MB II CHARGES

Further composition analysis were made [illegible] the remaining AN/FO charges in MB II even though fingerprinting data were not available from the charges to make comparisons to. Since free-air pressure measurements were not made off all the AN/FO charges, an attempt was made to compare crater efficiency (CE) to the FM values and FO percentages. Excluding the effect of geology, which there seems to have been none,

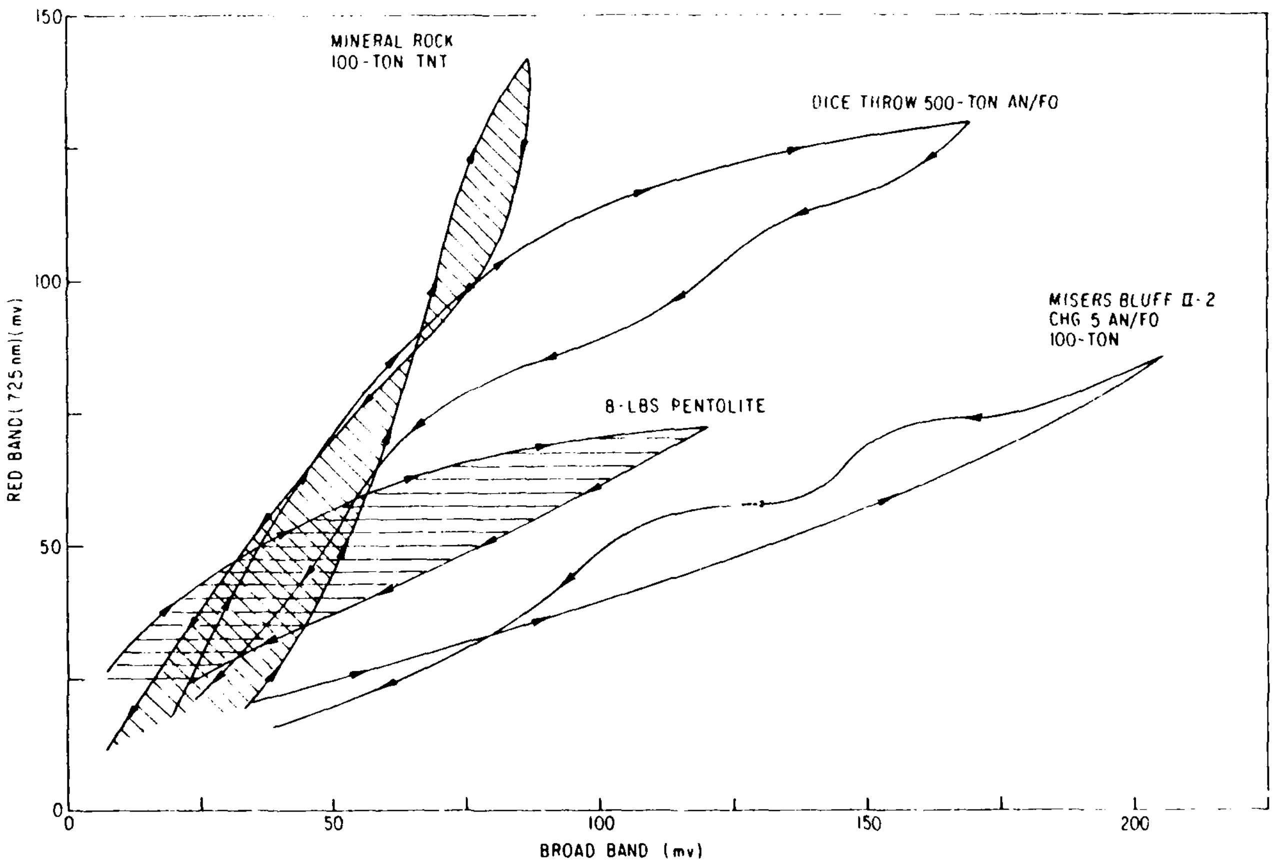


FIGURE 6 FINGERPRINTS FROM A NUMBER OF DIFFERENT TYPES OF HIGH EXPLOSIVES.

there was some tendency to show that CE may also have been effected by the values of FO and FM. The charge average fuel oil and crater volumes (ft^3) values for the MB II-1 and -2 Events are presented in Table 18.

TABLE 18. Charge Fuel Oil and Crater Volume for MB II

Event	Fuel Oil (percentage)	Crater Volume* (ft^3)
MB II-1	6.7 $\pm$ 1.3	54,400
MB II-2-1	5.6 $\pm$ 1.1	74,800
MB II-2-2	4.3 $\pm$ 1.3	73,000
MB II-2-3	6.0 $\pm$ 1.7	45,000
MB II-2-4	5.4 $\pm$ 0.7	37,700
MB II-2-5	5.3 $\pm$ 1.2	66,400
MB II-2-6	6.0 + 1.2	80,500

*Preliminary data from Benson, K et al, MISERS BLUFF, Phase II, MISERS BLUFF Symposium, March 27-29, 1979.

The FM values for the seven AN/FO charges in MB II-1 and 2 Events are presented in Table 19. Note that all the charges had FM values which were much less than the values for PDT II-2 and DT AN/FO charges.

TABLE 19. FM Tabulation For MB II-1 and -2 Charges

Charge	Sieve Size								FM
MB II	Pan	35	20	16	14	12	10	6	
1	100	98	91	77	55	25	6	0	4.52
	2	7	14	22	30	19	6	0	--
2-1	100	99	91	80	67	41	15	0	4.92
	1	8	11	13	26	26	15	0	--
2-2	100	99	90	72	56	33	11	0	4.61
	1	9	18	16	23	22	11	0	--
2-3	100	98	90	72	57	36	13	0	4.66
	2	7	18	15	21	23	13	0	--
2-4	100	99	91	75	59	34	12	0	4.70
	1	8	16	16	25	22	12	0	--
2-5	100	99	92	72	56	32	11	0	4.62
	1	7	20	16	24	21	11	0	--
2-6	100	99	94	85	70	47	20	0	5.15
	1	5	9	15	23	27	20	0	--

Comparisons were made to the CE for the MB II charges by assigning position numbers for CE, FM, FO and the boosters' simultaniety of initiation (1); whereby, the value of one (1) was assigned to the largest values of CE and FM, to the closest value of FO to 6 percent with the lowest percent deviation and to the best simultaniety of booster detonations (1) and then in decreasing order to a value of seven (7), (see Table 20 for the assigned values for the different parameters). The lower the assigned number is, better is the value of the specific parameter.

TABLE 20. Assigned Position Numbers to Different Parameters From The MB-II Events

Charge	CE	I	FM	FO
1	5	2	7	6
2-1	2	4	2	3
2-2	3	5	5	7
2-3	6	3	3	2
2-4	7	6	4	4
2-5	4	7	6	5
2-6	1	1	1	1

The closest indication that all the parameters were as good as possible was for charge 2-6. Since the assigned numbers were not weighted for the effects of each parameter on CE, the other CE values may have been effected by a change in geology as well as I, FM and FO. There were indications from on site geology that the further the charges were from the positions of charges 1 and 6, the more geological layering there was.[1]

[1]Preliminary data from Benson, K. et al, MISERS BLUFF, Phase II, MISERS BLUFF Symposium, March 27-29.

3.3 SURFACE-SURGE SHOCKWAVE SEPARATION DATA

The generation of a smooth and uniformly-expanding shock front in all directions away from SGZ along the air-surface interface is one of the most important features of a high explosive (HE) detonation.

The PDT and DT AN/FO Events indicated that the shockwave from the HEC charges separated much sooner than an equivalent TNT spherical charge placed tangent to the surface.

The results from MB II-1 and MB II-2, chg. 5 indicated slightly longer separation times and distances than did the DT Event. See Table 21.

TABLE 21. Times and Distances Where The Main Shockwave Separated From The Surface-Surge Fireball Expansion

Event	Time (ms)	Distance (m)	Distance (ft)
MB II-1	22.2	56.1	184
MB II-2, chg. 5	28.7	68.2	224
DT[1]	20.4	53.3	175

[1]*Scaled-down average of six readings*

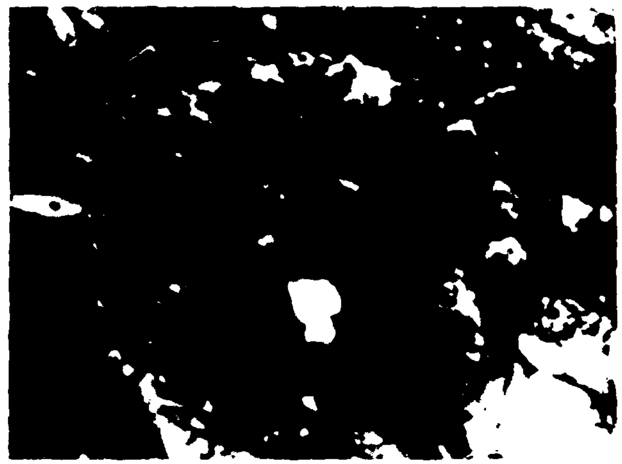
3.4 SURFACE-SURGE FIREBALL ANOMALIES

Surface-surge anomalies were photographed during the MB II-1, from both aerial and surface cameras. Figure 7 shows two anomalies from MB II-1 as photographed with an aerial camera. The multiple detonations of MB II-2 did not seem to produce obvious anomalies on the outer perimeter of the array as can be seen in the photographic sequence recorded above the event shown in Figure 8. Since fireball anomalies are generally photographed rather late in the fireball expansion phase, anomalies may have existed in between the charges for the MB II-2 Event but were interacted before they could be formed outside their main fireball expansions. As a result only the anomalies from MB II-1 Event are presented in the report.

SETUP

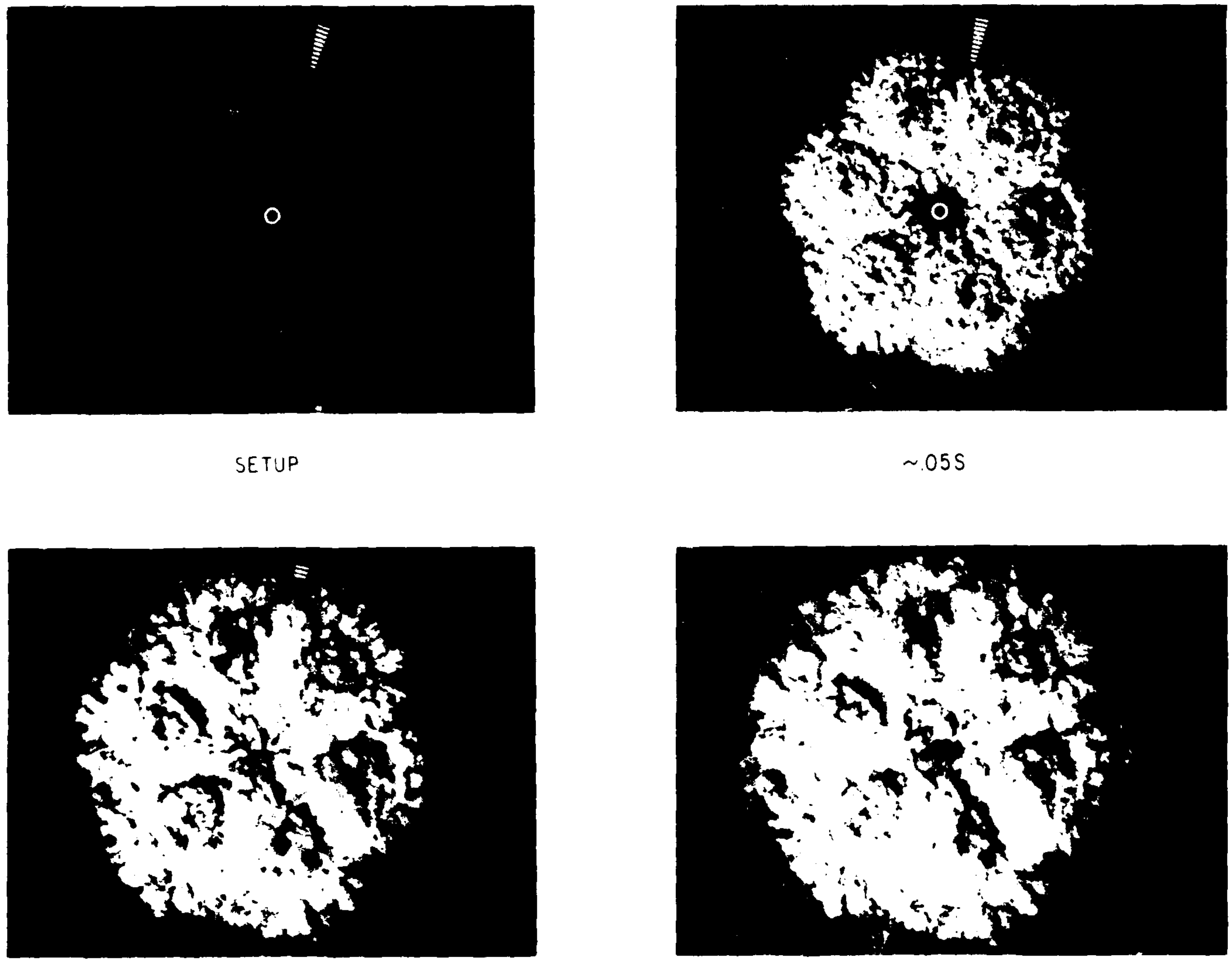
~.05S

~.1S



~.15S

FIGURE 7. AERIAL SEQUENCES FROM MBE-1 @ 20 FR/S SETUP THRU ~.15S



SETUP ~.05S ~.1S ~.15S

FIGURE 8 AERIAL SEQUENCES FROM MBII-2 @ ~20 FR/S, SETUP THRU ~.15S.

Table 22 indicates that there were four major anomalies from MB II-1 and that their initial expansions were near those observed from the DT Event.

TABLE 22. Times, Directions and Distances where the Shockwave Passed the Surface-Surge Anomalies

Event	Time (ms)	Direction (degrees)	Distance (m)	Distance (ft)	Height (m)	Height (ft)
MB II-1	120[1]	123[2]	133	435	12.2	39.9
MB II-1	98[1]	289[2]	120	393	7.7	25.2
MB II-1	100[2]	226[2]	102	336	-	-
MB II-1	150[2]	351[2]	126	412	-	-
DT[3]	107	329	138	453	5.9	19.2
DT[3]	102	344	135	441	6.2	20.4
DT[2,3]	-	208	(+)[4]	(+)[4]	-	-

[1] Ground level Fastax Cameras (4800 fr/s); time and spatial resolution good.
[2] Overhead Hulcher Camera (20 fr/s); off-axis view, angular resolution good, spatial resolution good, time resolution poor.
[3] Scaled-down data to MB II-1.
[4] Went out of view of camera.

3.5 DYNAMIC EJECTA

The MB I Events generally produced more dynamic ejecta which travelled beyond the fireball surface-surge region than did MB II Events. The main reason for the difference was due to the crater related geologies between the two test sites. The Queen 15 test site had much more cohesive soil with a water table near the test surface; whereas, the McCormack Ranch site had deposited sand and gravel with little cohesiveness and low water table.

As expected the half-buried detonations of MB I Series produced much more dynamic ejecta than the surface tangent detonations. See Figures 9 and 10. Figure 11 presents a sequence from MB II Series. Note that there were no obvious ejecta throwout beyond the fireball debris.

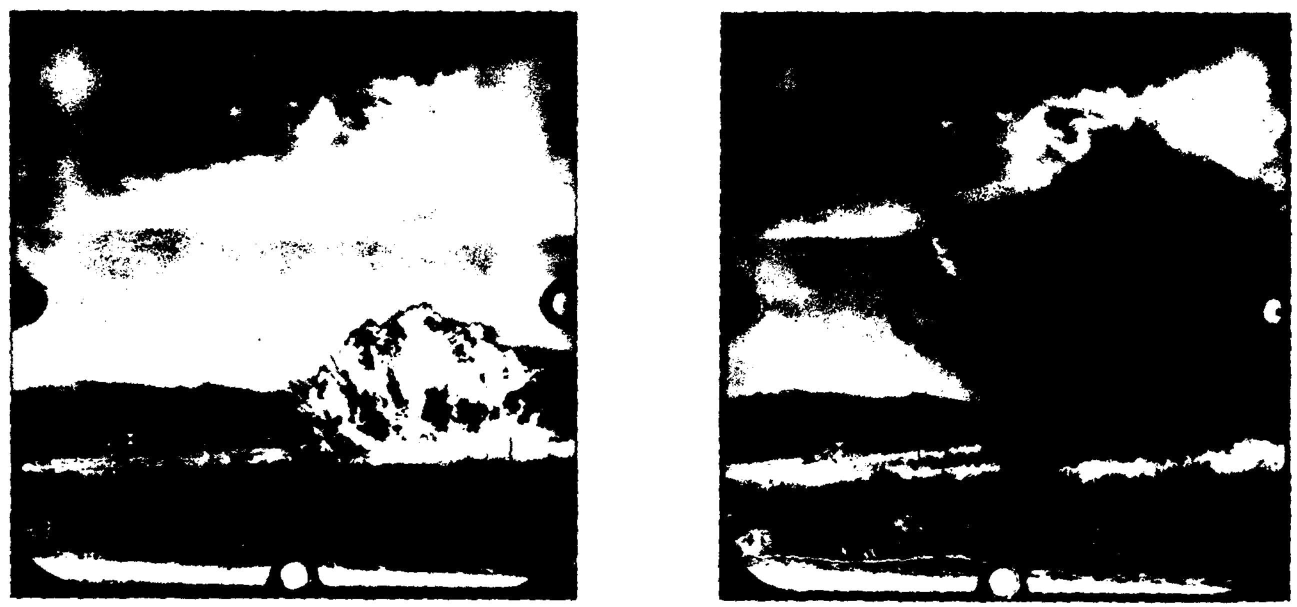
3.6 CLOUD DATA

Cloud measurements were made on a number of the photographic sequences from MB I and II Events. The data are based on measurements made from only one camera aspect and with a fixed scale (preshot, referenced in SGZ), i.e., no adjustments were made for photographic scale changes during tracking.

3.6.1 Cloud Height and Diameter Data from MB I Events

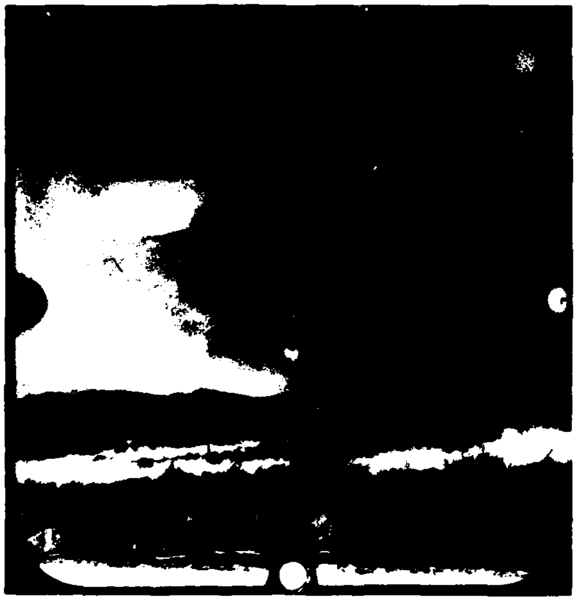
The cloud height versus time plots from the single and multiple events of MB I are presented in Figures 12 and 13 respectively; whereas, the diameter versus time plots from the single and multiple events of MB I are presented in Figures 14 and 15 respectively. These data were obtained from the photographic records made at the southwest camera station since this station did obtain records with the least change in scale due to the cloud drift. See Figure 16. Table 23 presents the distances from the two 70mm recording cameras during MB I series.

In general, the plots indicate that the full- and half-buried single charges produce clouds that rose faster and higher than the clouds produced by the same weight of charge placed tangent to an equivalent surface. See Figures 17 and 18. There appears to be, for some

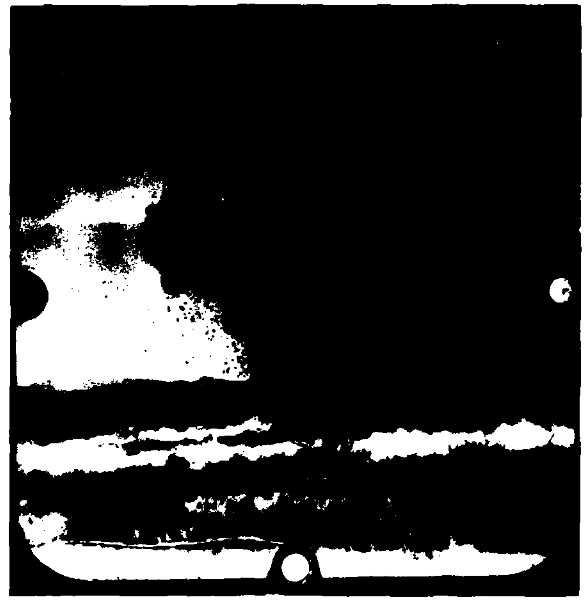


~ .05S .5S

FIGURE 9. DYNAMIC EJECTA SEQUENCE FROM MBI-1 @ 20FR/S, 1000LB. SPHERE, HALF BURIED.

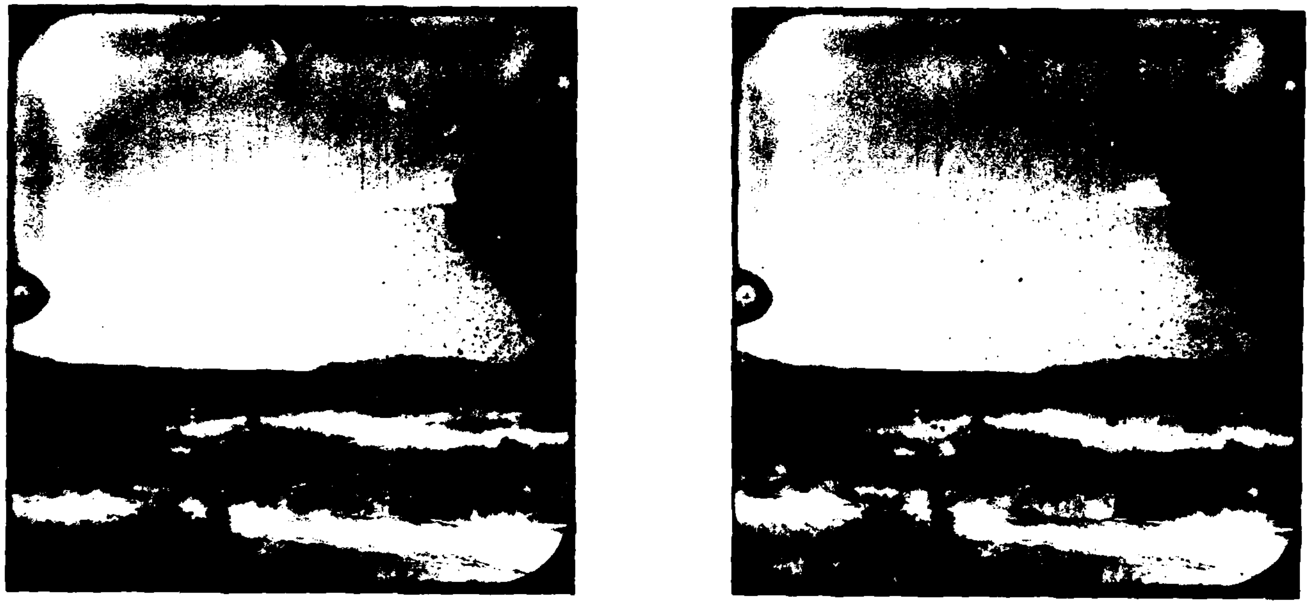


1S



2S

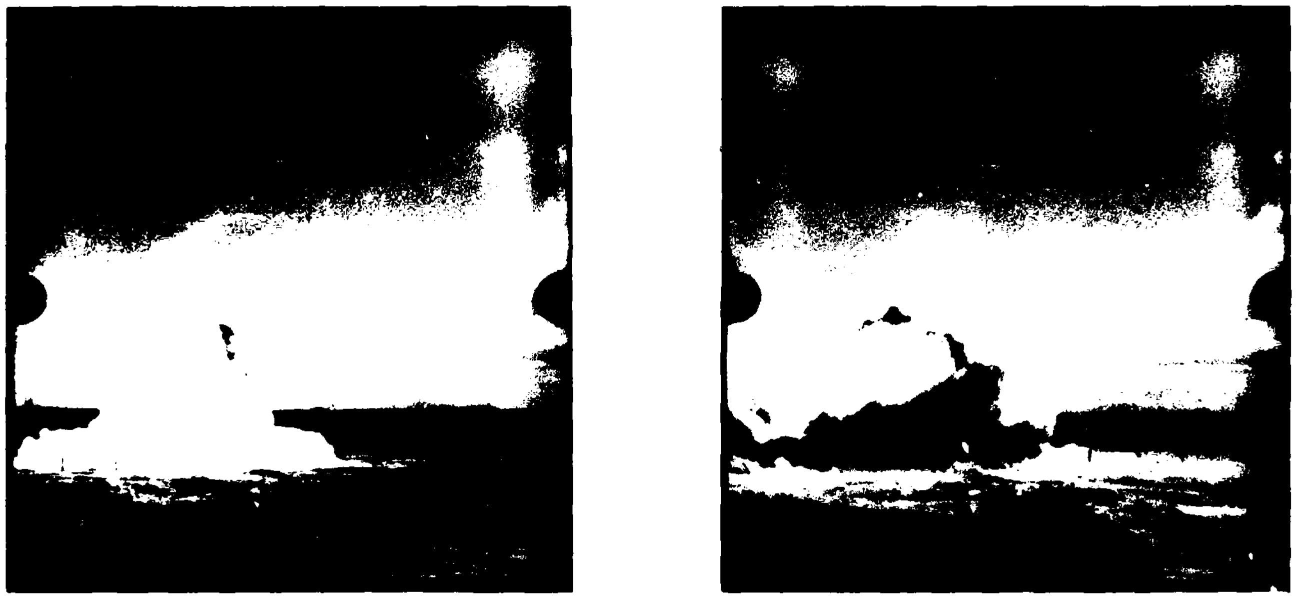
FIGURE 9 (CONTINUED)



3S

4S

FIGURE 9 (CONTINUED)

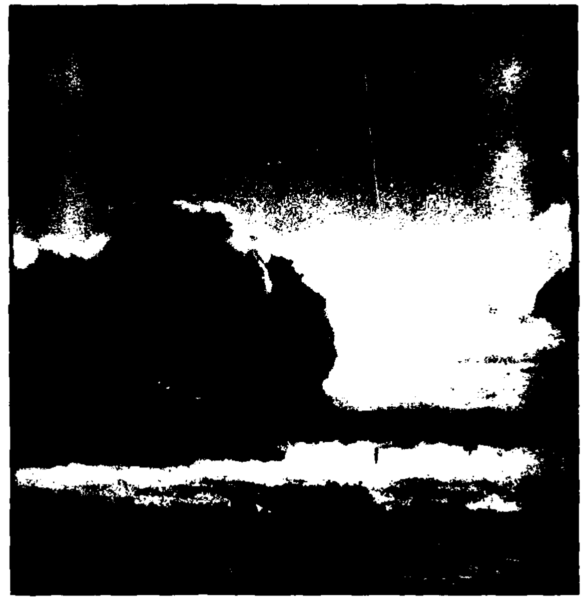


~.05 S

.5 S

FIGURE 10. DYNAMIC EJECTA SEQUENCE FROM MBI-2 @ 20 FR/S, 1000 LB SPHERE SURFACE TANGENT ABOVE.

1 S



2 S

FIGURE 10.(CONTINUED)

SETUP

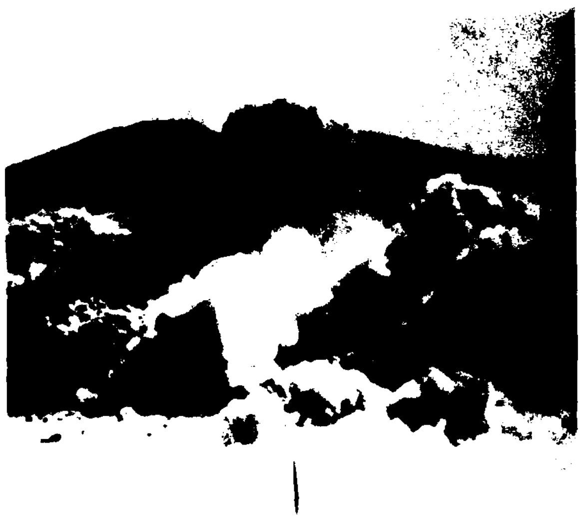
~.05S

FIGURE 11. DYNAMIC EJECTA SEQUENCE FROM MBII-2 @ 22.4 FP/S

.25 S

1 S

FIGURE 11.(CONTINUED)



1.5 S

2 S

FIGURE 11. (CONTINUED)

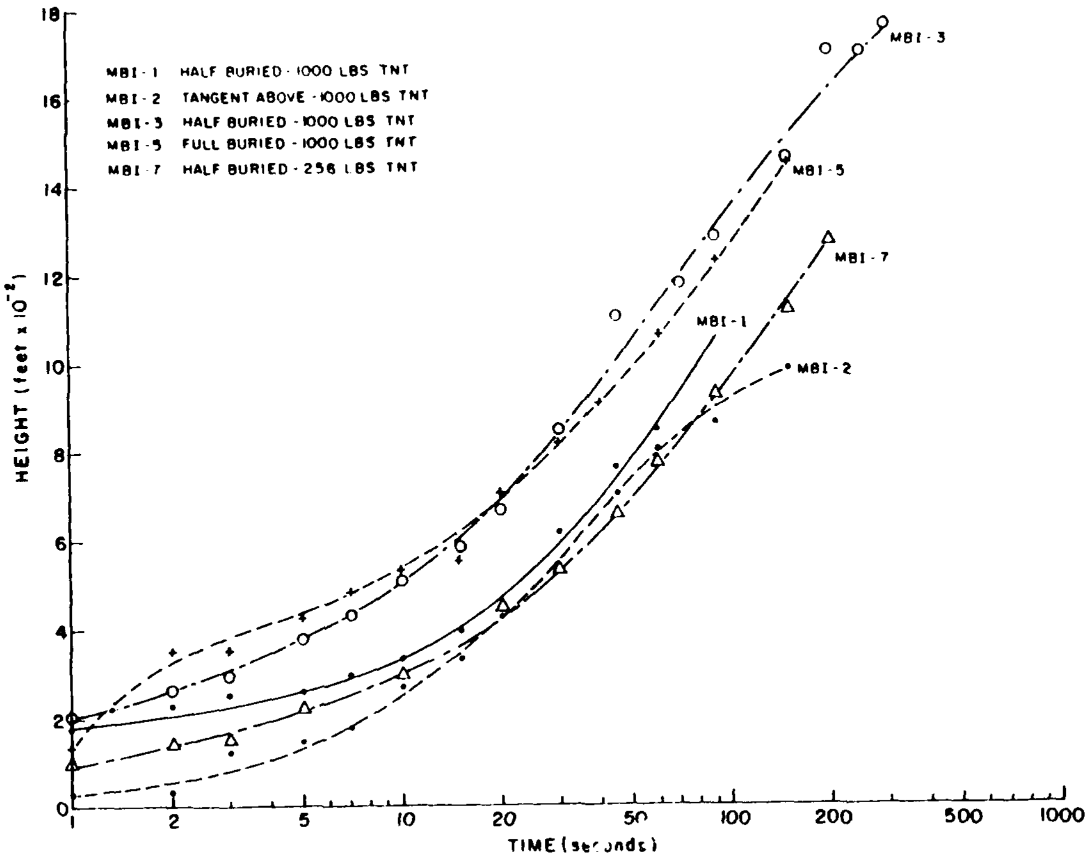


FIGURE 12. CLOUD HEIGHT vs TIME FROM MISERS BLUFF I SINGLE EVENTS, SOUTHWEST CAMERA, FIXED SCALE

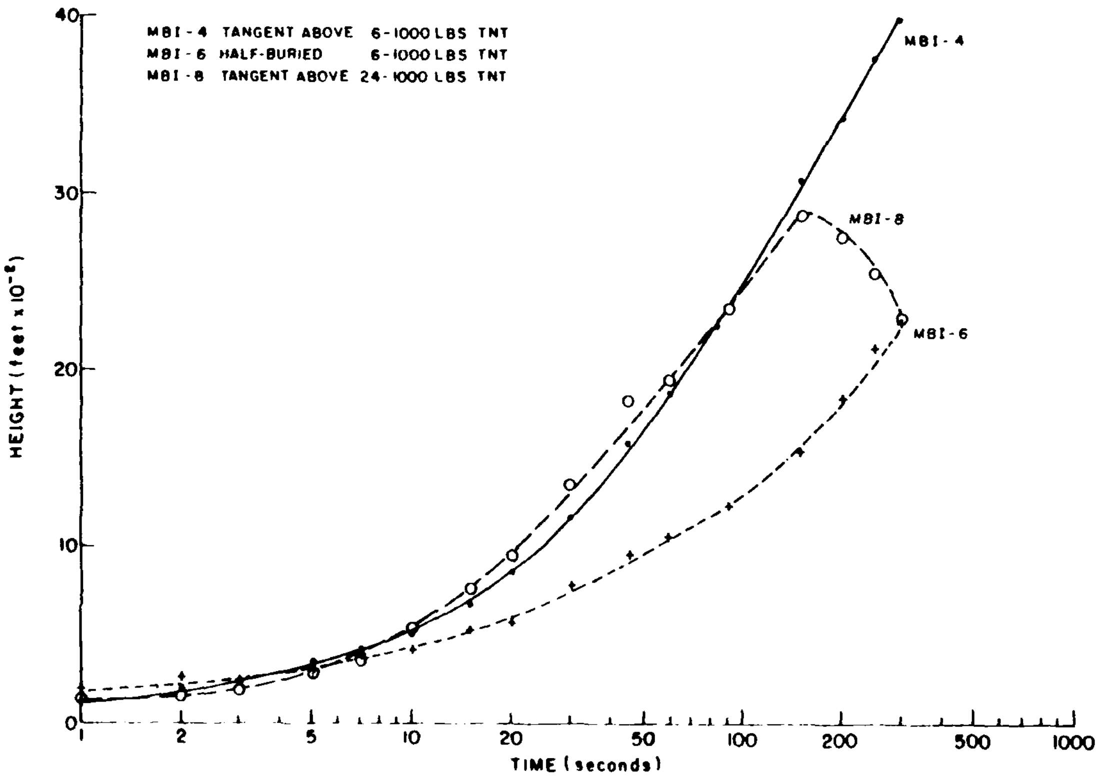


FIGURE 13 CLOUD HEIGHT vs TIME MISERS BLUFF I MULTIPLE EVENTS, SOUTHWEST CAMERA, FIXED SCALE.

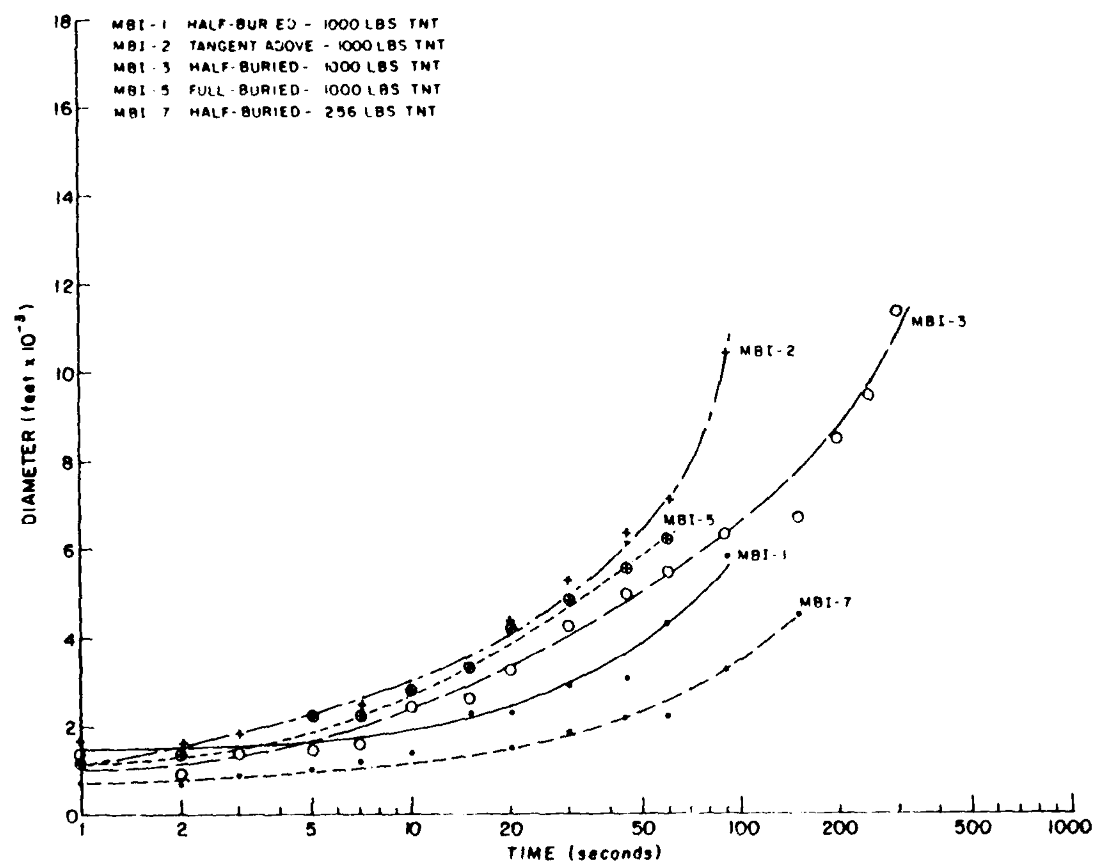


FIGURE 14. CLOUD DIAMETER vs TIME FROM MISERS BLUFF I SINGLE EVENTS, SOUTHWEST CAMERA, FIXED SCALE

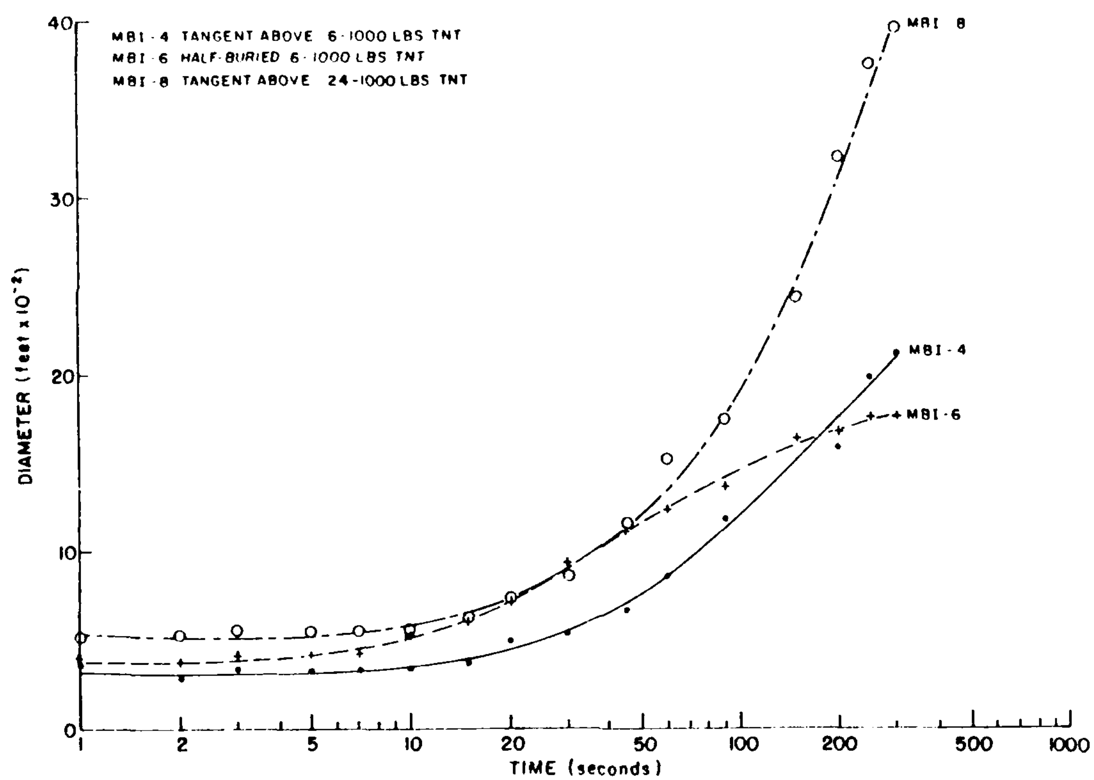


FIGURE 15 CLOUD DIAMETER vs TIME FROM MISERS BLUFF I MULTIPLE EVENTS, SOUTHWEST CAMERA, FIXED SCALE

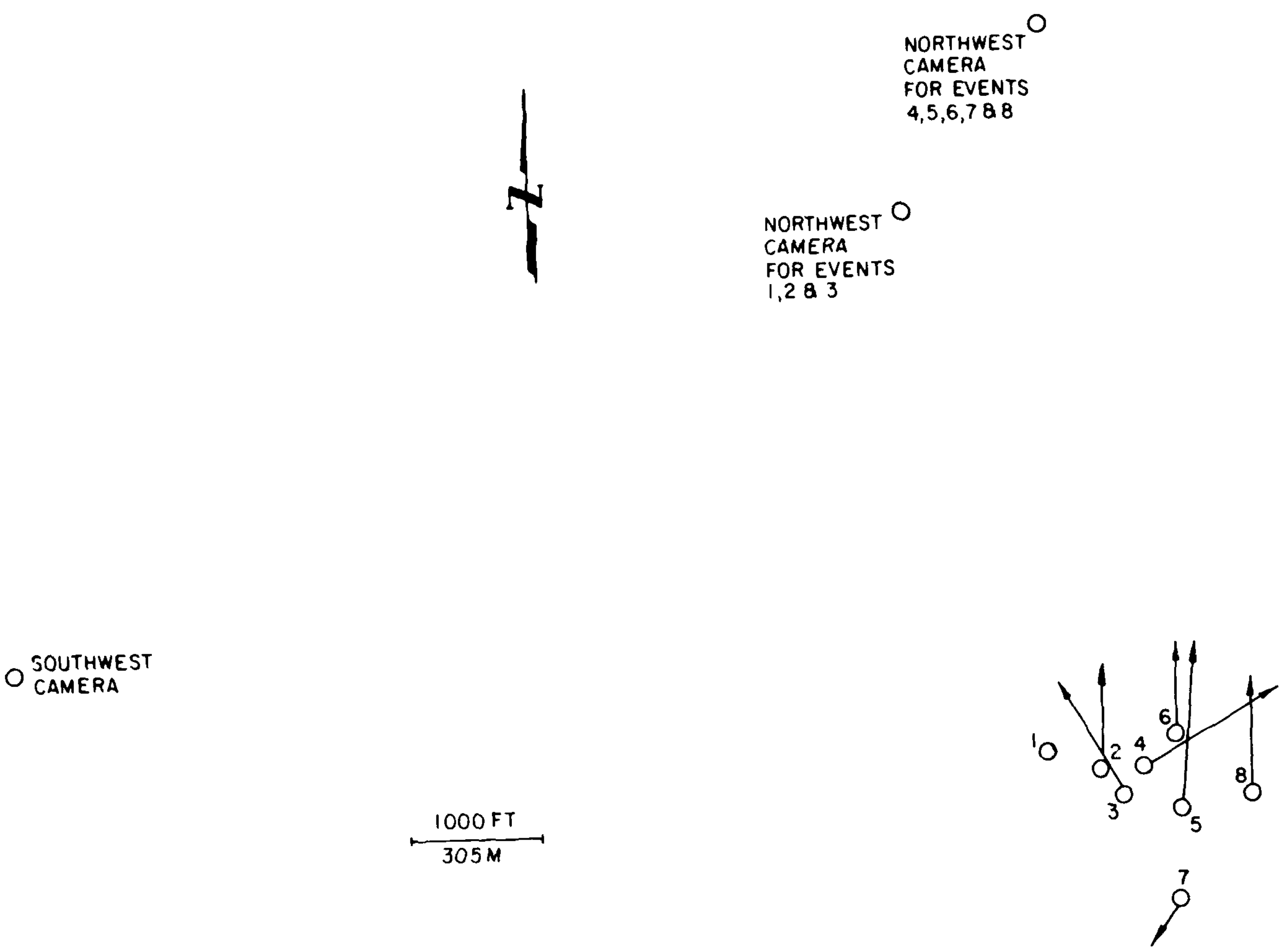


FIGURE 16. SGZs AND WIND DIRECTIONS FOR MBI EVENTS.

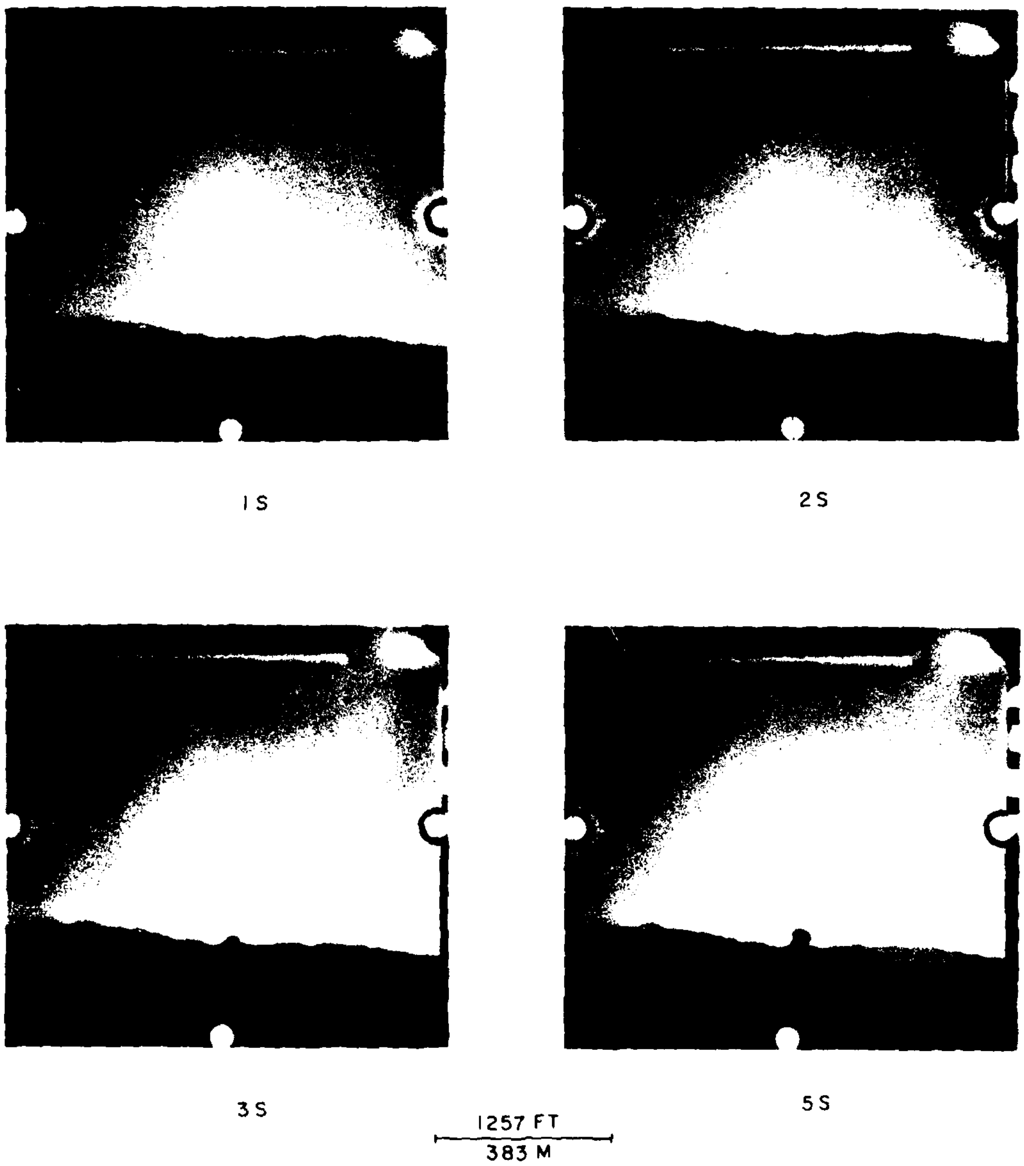


FIGURE 17. CLOUD SEQUENCE FROM MBI-3, SOUTHWEST CAMERA @ 5.93 FR/S, HALF BURIED.

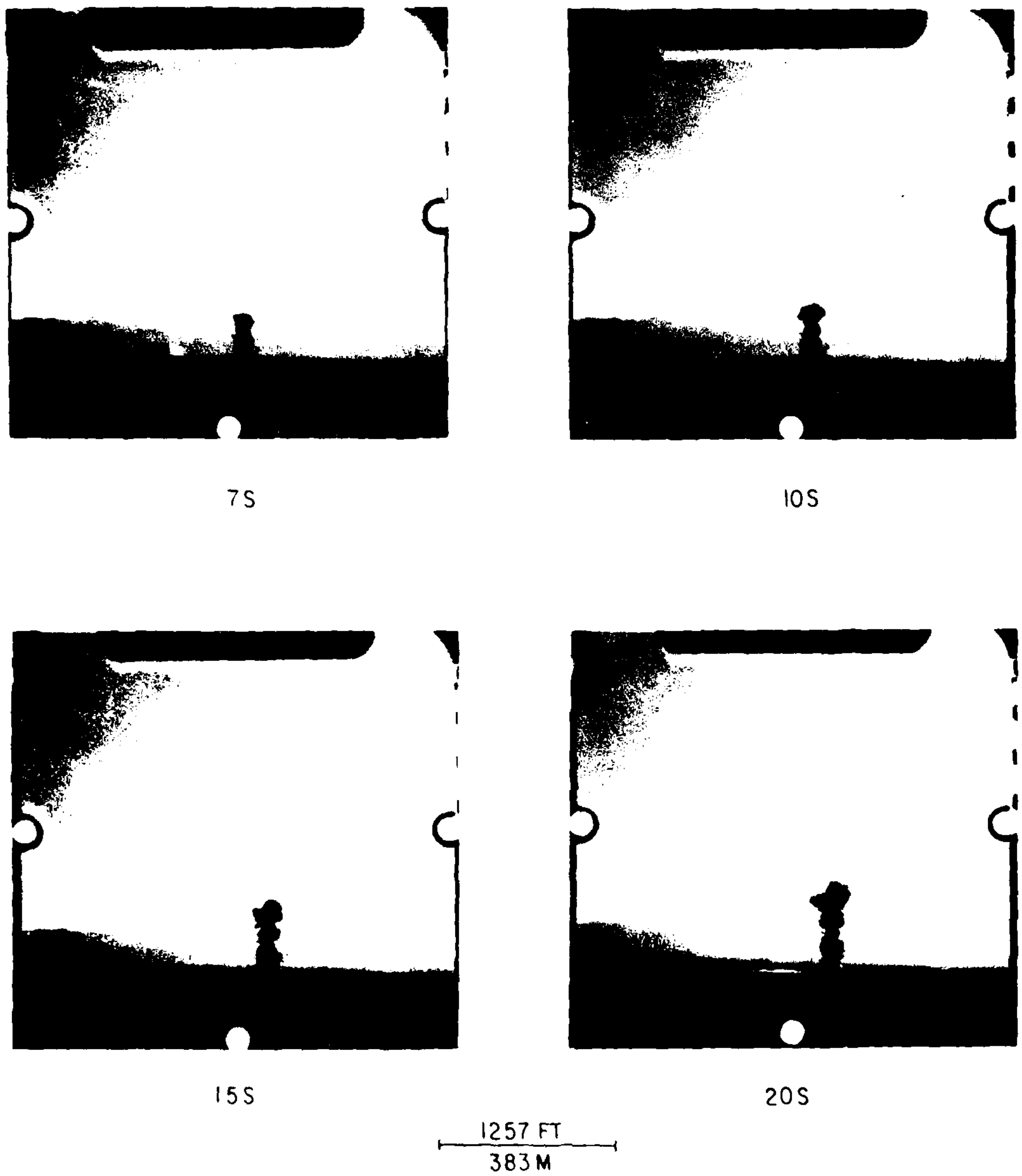


FIGURE 17 (CONTINUED)

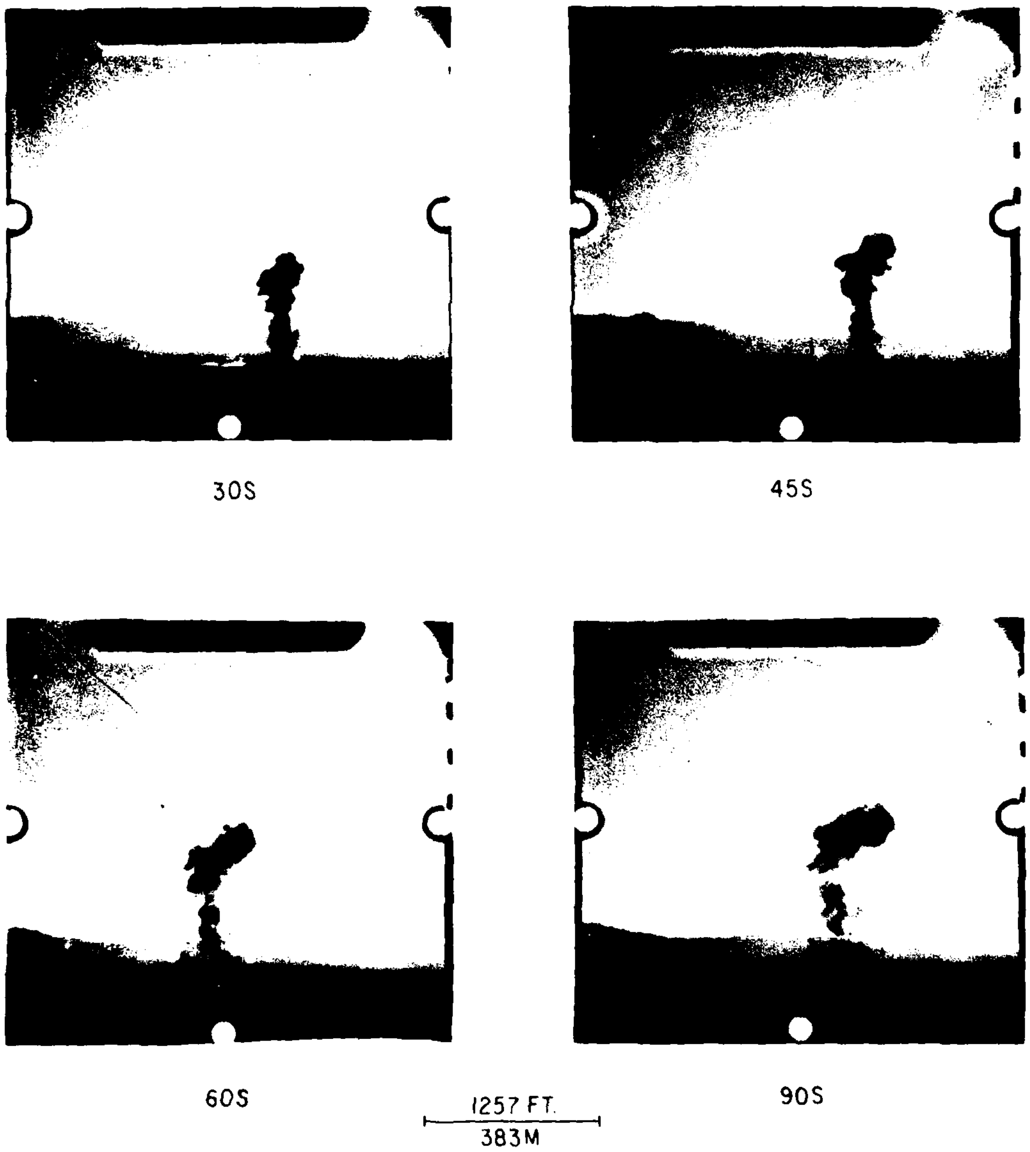


FIGURE 17. (CONTINUED)

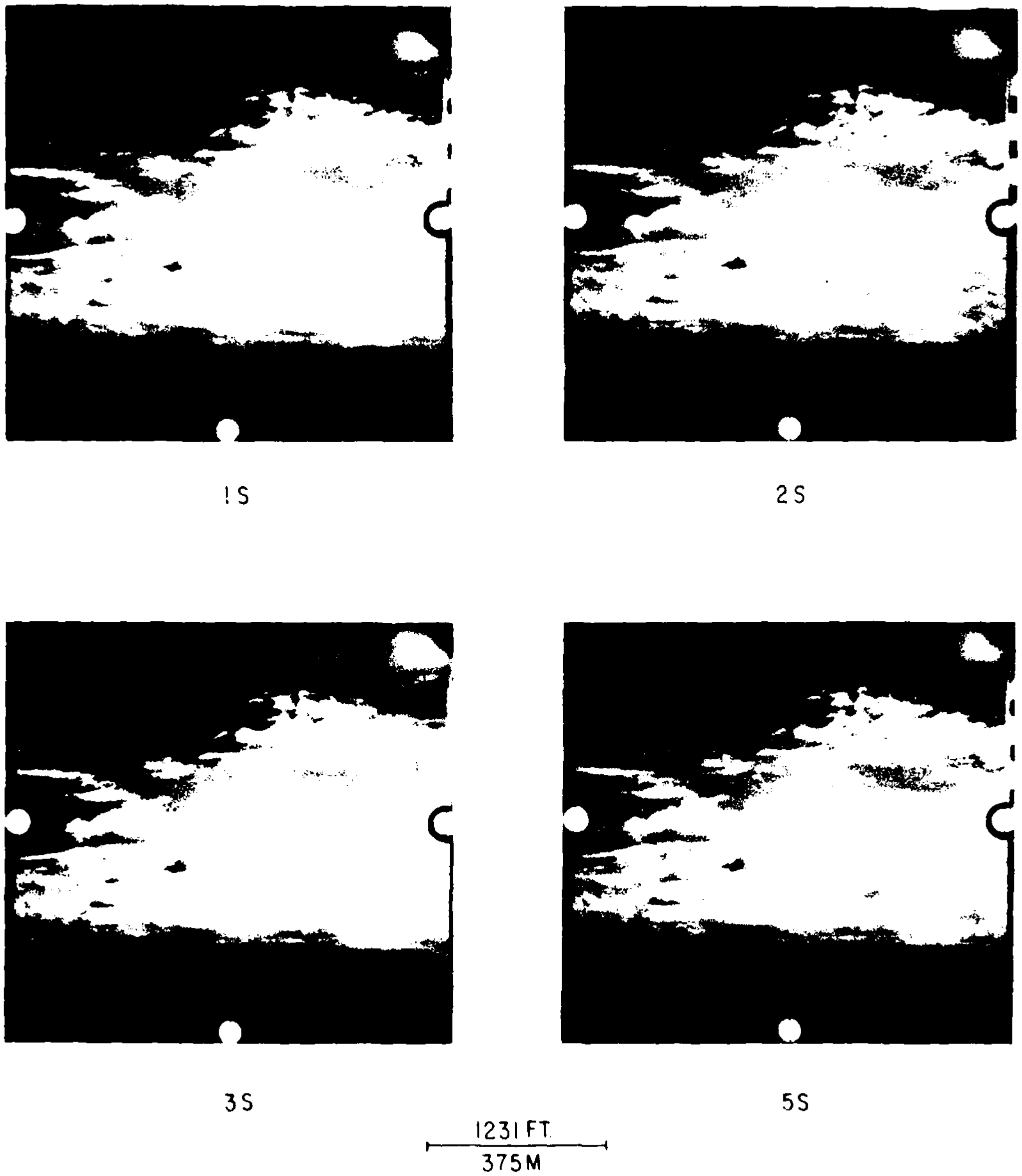
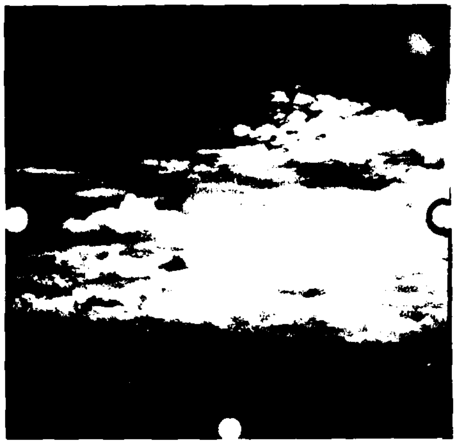
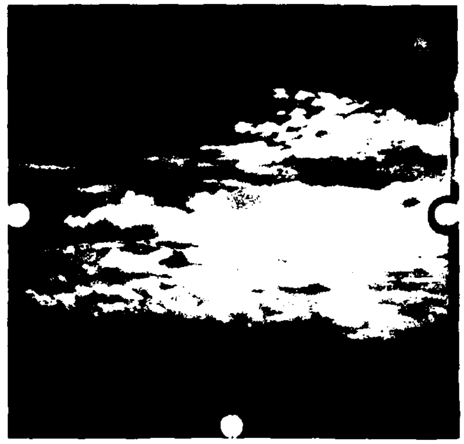


FIGURE 18. CLOUD SEQUENCE FROM MBI-2, SOUTHWEST CAMERA
@ 5.19 FR/S, SURFACE TANGENT ABOVE

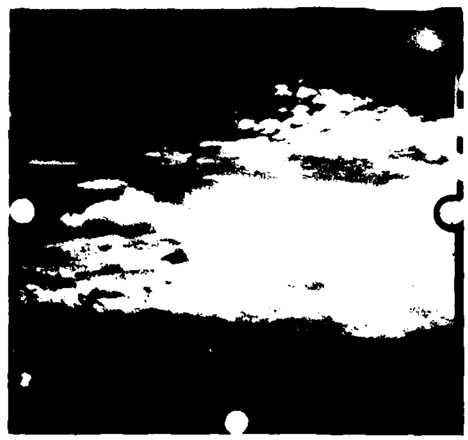


7S



10S

15S

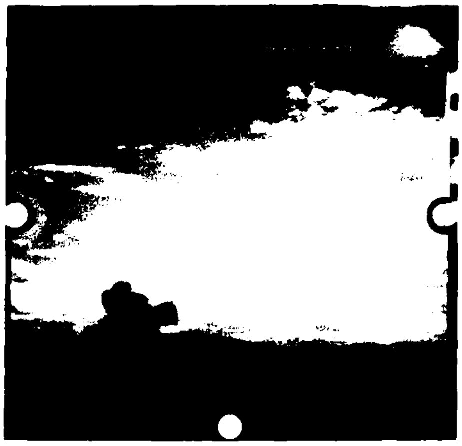


20S

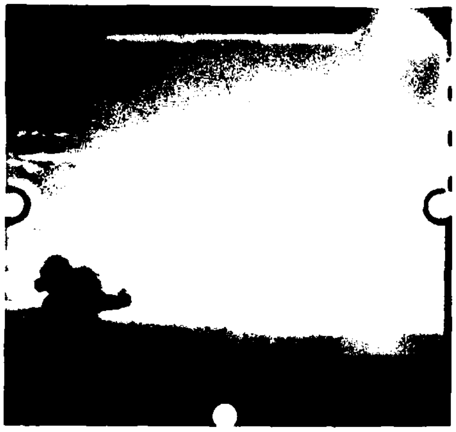
1231 FT
375 M

FIGURE 18 (CONTINUED)

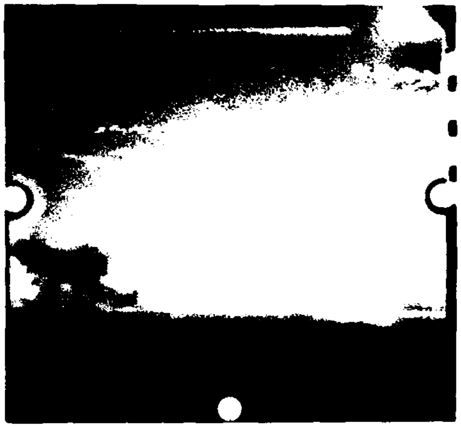
30S



45S



60S



90S

1231 FT

375 M

FIGURE 18.(CONTINUED)

Table [illegible] to SGZ and from Camera to Camera for MB I Events

Event Number	[illegible] (ft)	[illegible] (m)	NW Camera (ft)	NW Camera (m)	SW-NW Camera (ft)	SW-NW Camera (m)
1	[illegible]	[illegible]	4369	1332	7612	2320
2	[illegible]	2562	4596	1401	7612	2320
3	8580	2615	4854	1480	7612	2320
4	8681	2646	5784	1763	9299	2834
5	8966	2733	5973	1821	9299	2834
6	8798	2682	5508	1679	9299	2834
7	9025	2751	6125	1867	9299	2834
8	9480	2890	6092	1857	9299	2834

unexplainable reason, a difference in cloud height and rise between MB 1-1 and -3, which were supposedly equivalent experiments.

MB 1-7 cloud, which was produced by a 256-pound TNT sphere, rose, as expected, slower and lower than the clouds produced by larger charges in the same position relative to the same surface geology.

The cloud diameter versus time from single detonations appear to vary in inverse to their heights, i.e., greater in diameter lower the height at any specific time. (Ref. 13). In other words, surface tangent (above) detonations produce greater diameter clouds after a short period of time than equivalent charges that are partially buried. Under this condition, it is surprising that MB 1-1 also produced a smaller diameter cloud than MB 1-3 even though it had a lower height of rise than the equivalent MB 1-3.

The multiple events appear to have produced clouds that rose contrary to their single charge counterparts which had the relative same position of the charge with respect to the surface geology, i.e., half-buried or tangent above. The surface-tangent, hexagonal array of MB 1-4 produced a cloud that rose faster and higher than the half-buried, hexagonal array of MB 1-6. Part of this effect may have been due to the difference in spacings between the charges in the hexagonal arrays.

Surprisingly, the surface-tangent, multiple-hexagonal array (24) of MB 1-8 produced a cloud that did not rise much faster than the smaller array of MB 1-4 and it did not even attain the same maximum height. The MB 1-8 cloud rise may have been hampered by an inversion layer at approximately 3000 ft (914 m).

As expected, the MB I-8, 24-charge array did produce a maximum cloud diameter which was much greater than those produced by either one of the smaller arrays of MB I-4 or -6. In addition, all multiple events did produce much faster cloud rise and greater cloud heights and diameters than anyone of the single charge detonations. Compare Figure 18 with Figure 19.

3.6.2 Cloud Height and Diameter Data from MB II Events

The cloud height versus time and cloud diameter versus time for MB II Events are presented in Figures 20 and 21 respectively. After a period of time, the multiple detonation of MB II-2 produced a much faster cloud rise and attained a much greater cloud height than the cloud from the single detonation of MB II-1. Similar effects are noted in the cloud diameter. Figure 22 presents a sequence from MB II-2.

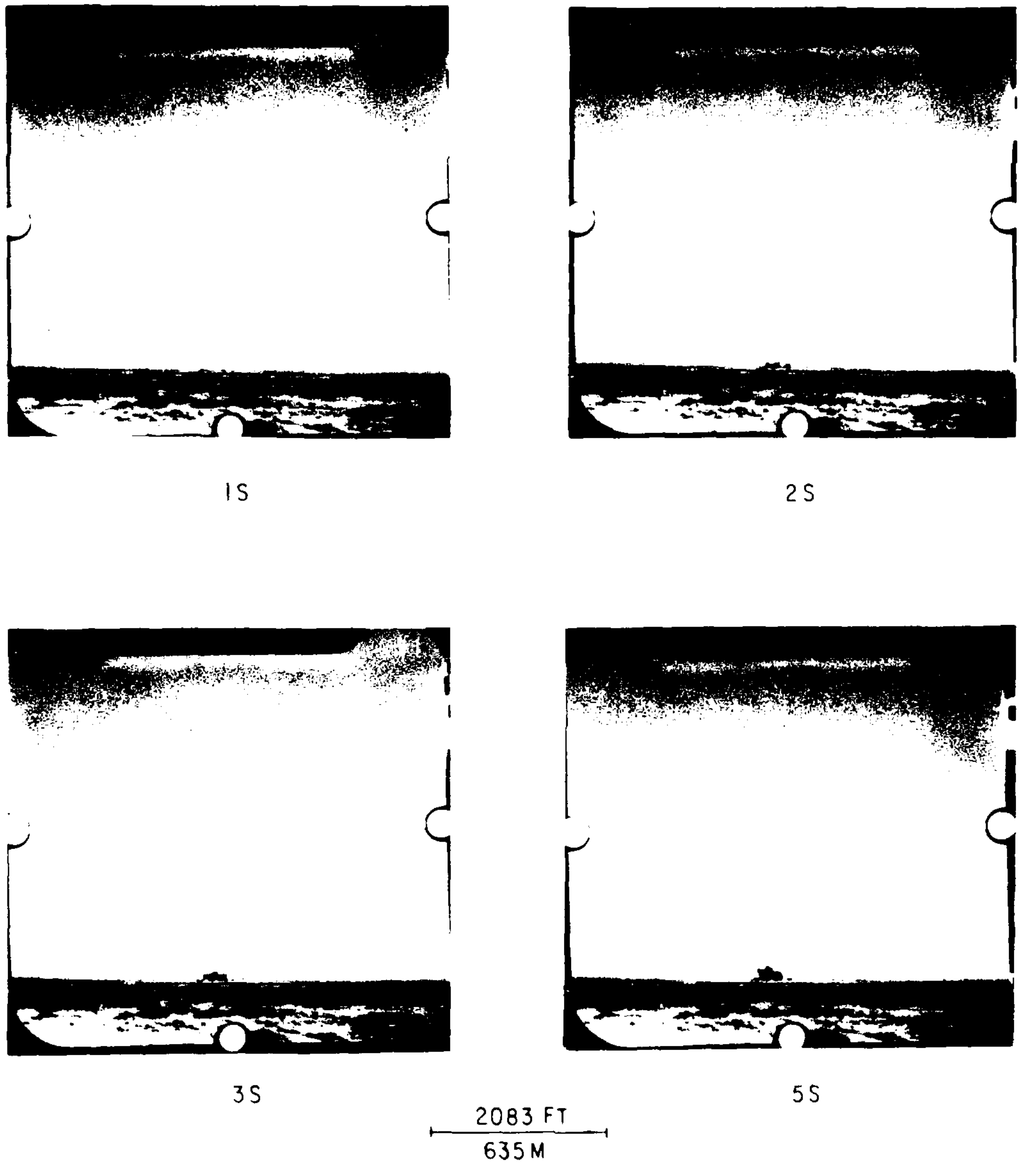
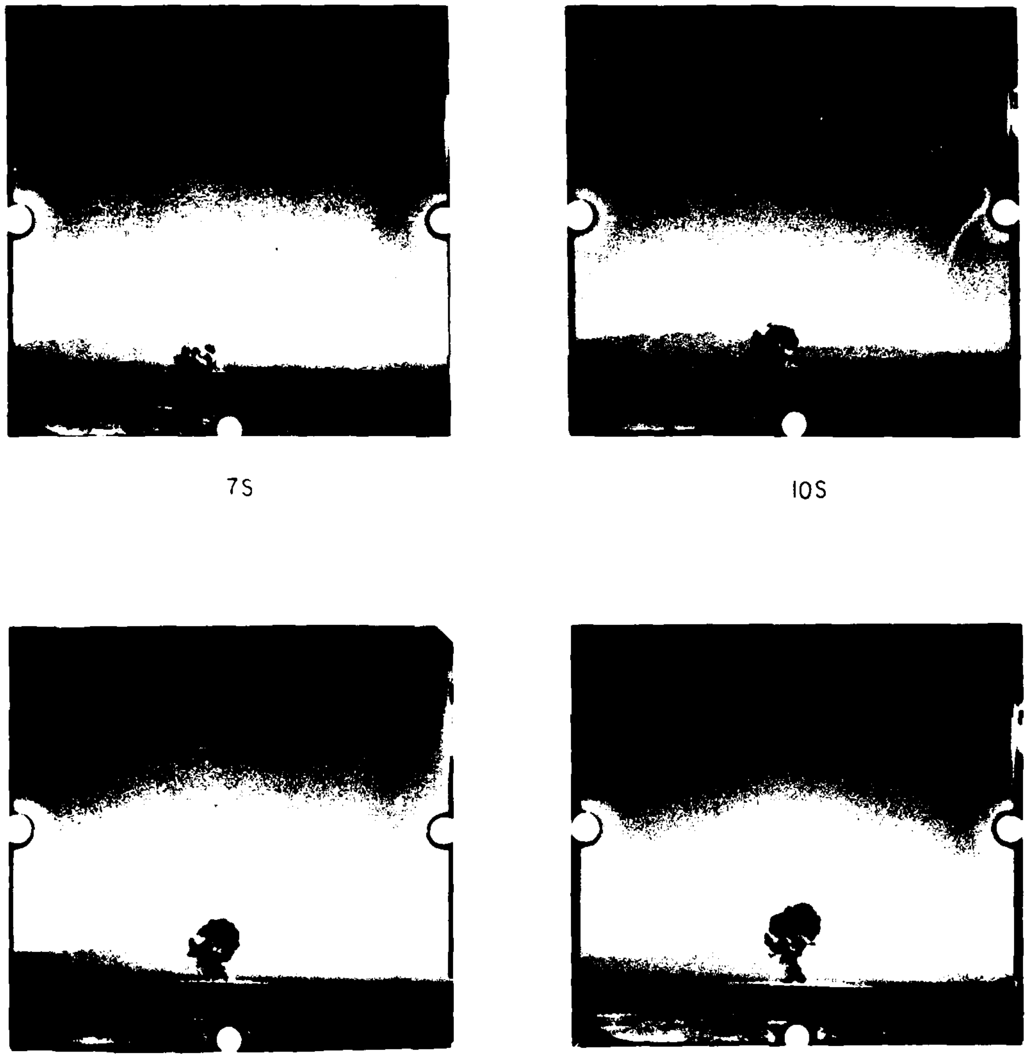


FIGURE 19 CLOUD SEQUENCE FROM MBI-8, SOUTHWEST CAMERA @ 6.01 FR/S 24-1000 LBS SPHERES, SURFACE TANGENT ABOVE.

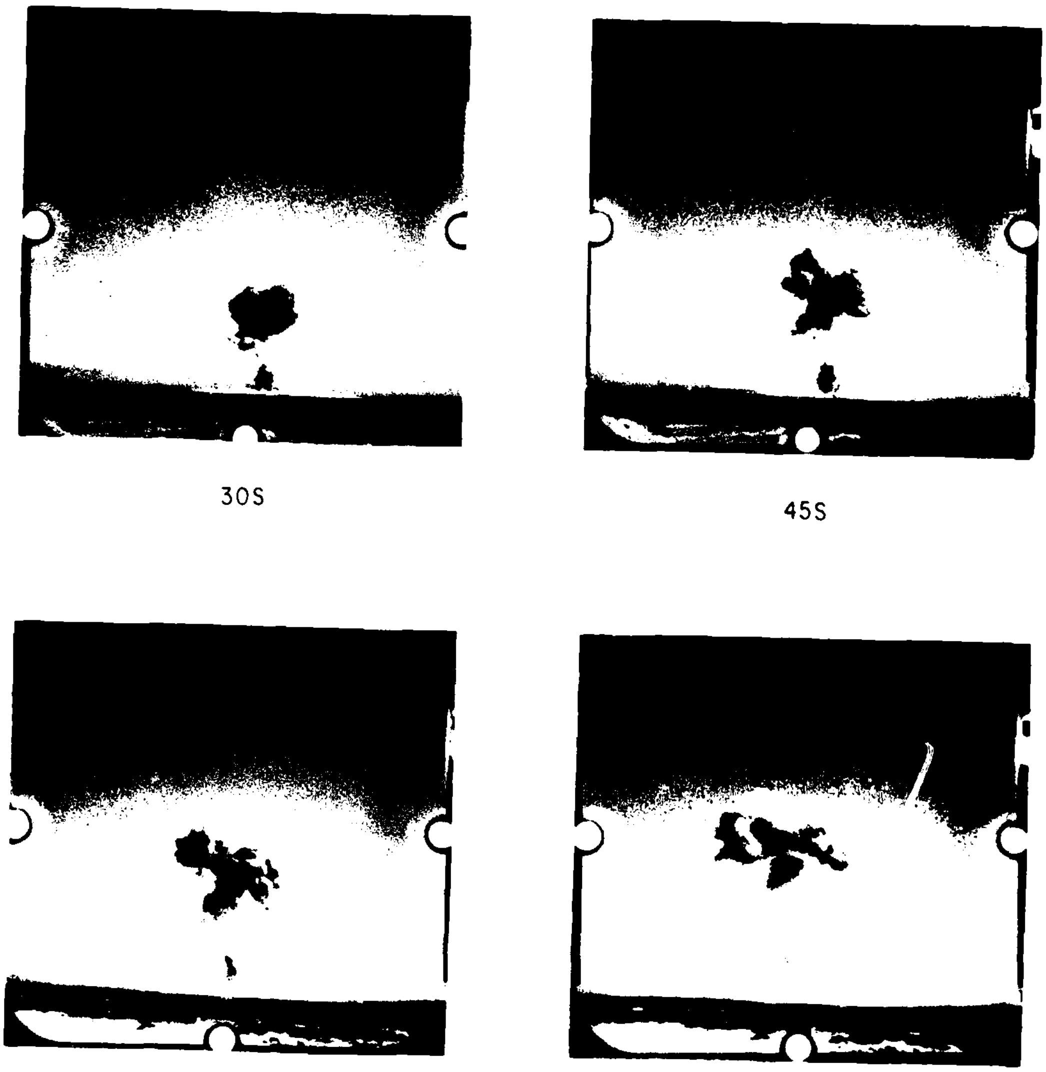


7S 10S

15S 20S

2083 FT.
635 M

FIGURE 19. (CONTINUED)



30S

45S

60S

90S

2083 FT
635 M

FIGURE 19. (CONTINUED)

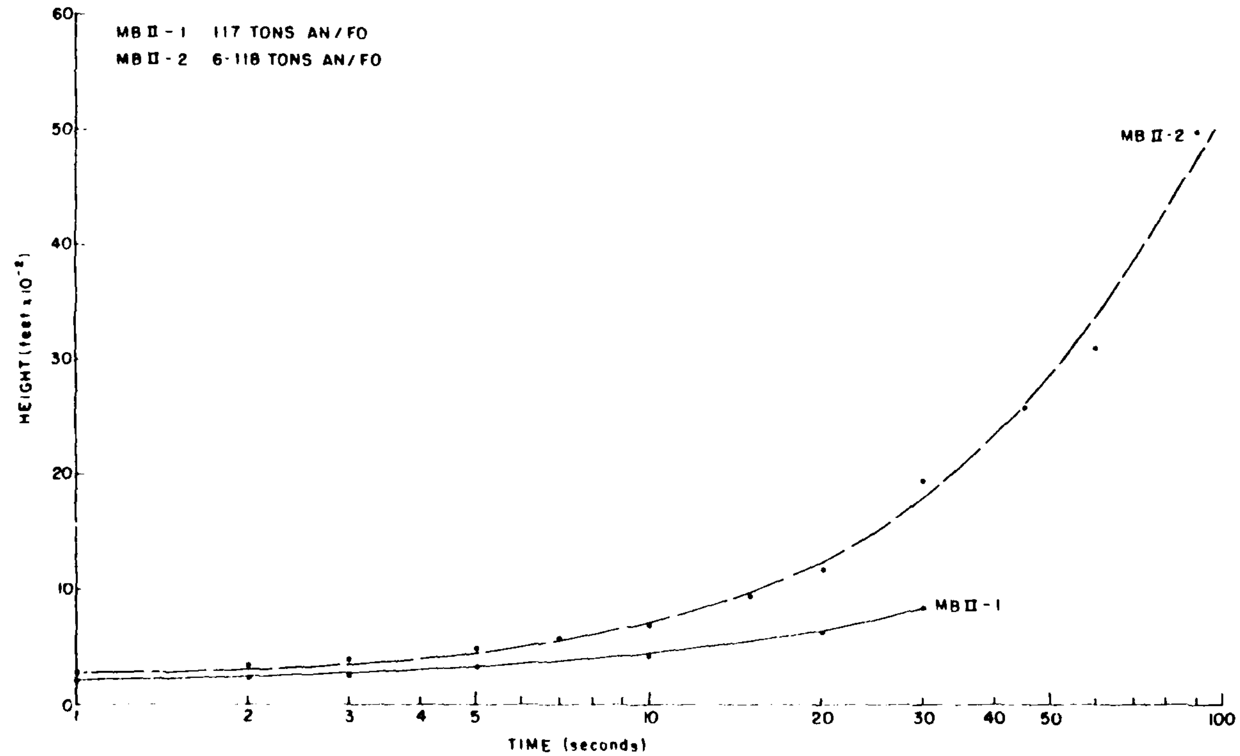


FIGURE 20 CLOUD HEIGHT vs TIME FROM MISERS BLUFF II EVENTS, FIXED SCALE

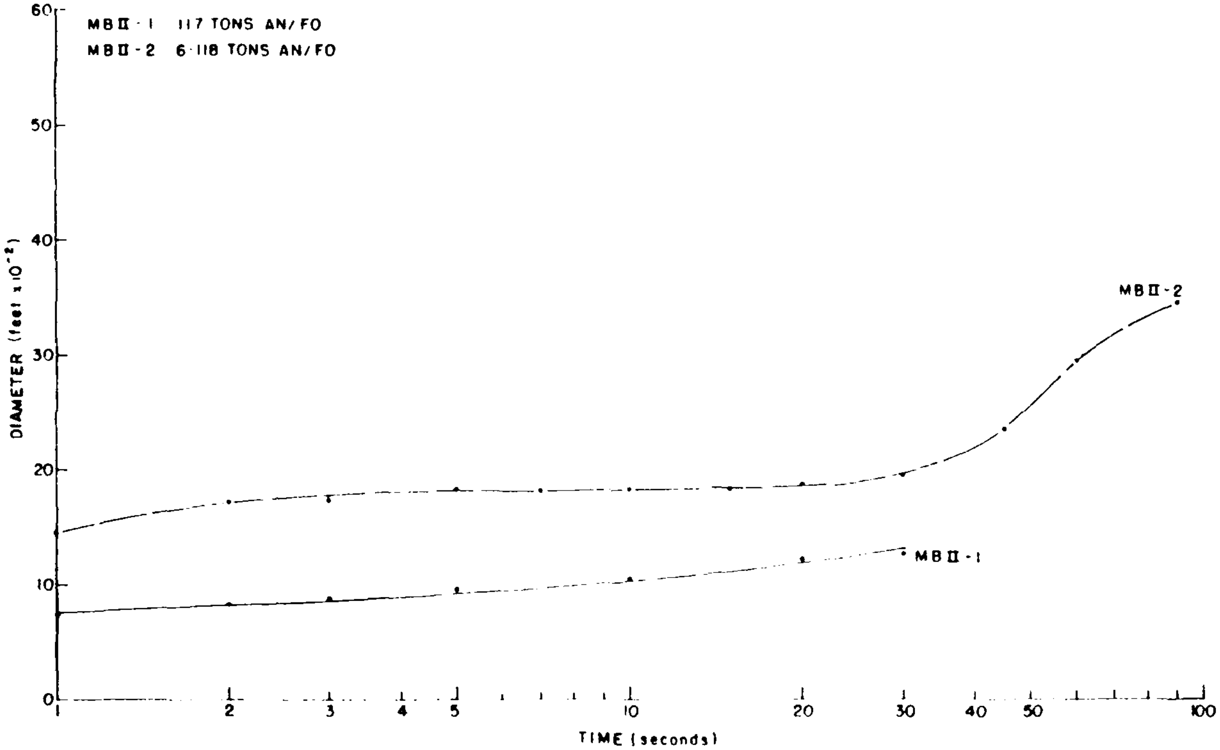
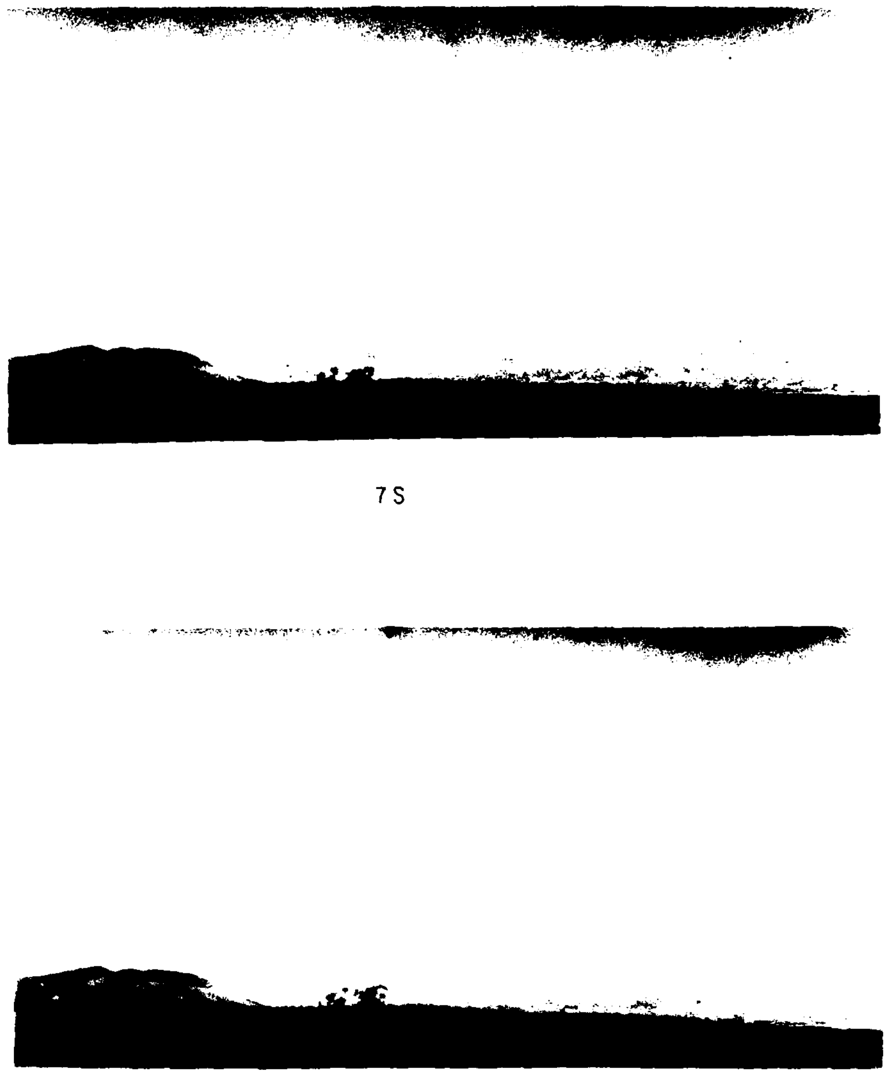


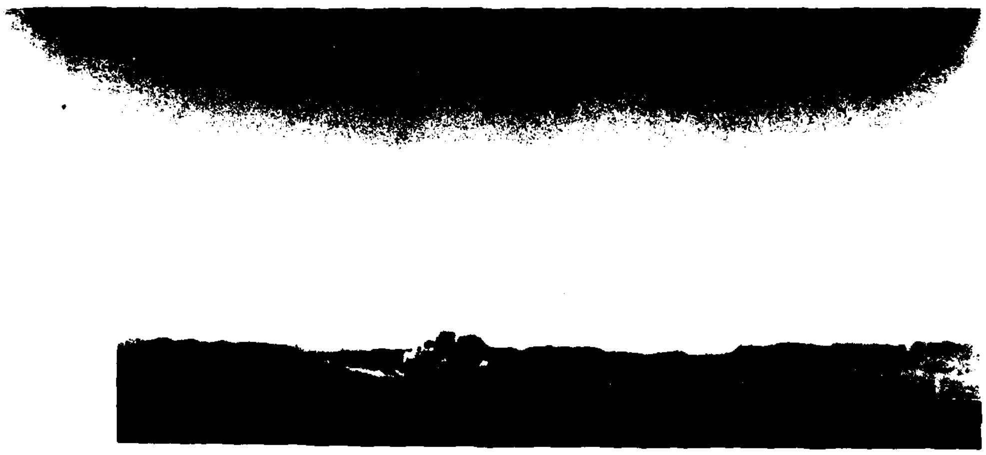
FIGURE 21 CLOUD DIAMETER vs TIME FROM MISERS BLUFF II EVENTS, FIXED SCALE



3345 FT
1020 M

FIGURE 22. CLOUD SEQUENCE FROM MBII-2, NORTH CAMERA @ 1 FR/S
6-118 TONS HEC CHARGES.

15S



20S

3345 FT

1020 M

FIGURE 22. (CONTINUED)

30S

45S

1345 FT

1020 M

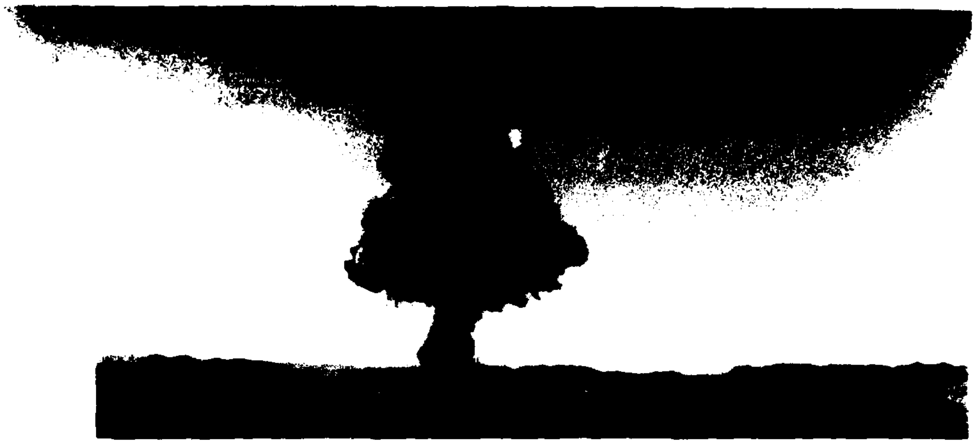
FIGURE 22. (CONTINUED)

60 S

90 S

3345 FT
1020 M

FIGURE 22. (CONTINUED)



150 S

200 S

3345 FT.
1020 M

FIGURE 22 (CONTINUED)

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

The photographic coverage for the MB I Series appeared to be more than adequate for the detonation parameters desired. The photographic coverage of the clouds during MB II Events was limited by camera failures and wind conditions.

For 1000-pound, spherical detonations, distances of 9000 ft (2743 m) from SGZ to the recording 70mm cameras appears to be adequate to photograph cloud development and rise for a period of 300 s through a 100mm lens. An angular separation of 90 to 120 degrees down wind of SGZ would appear to be ideal for future coverage. Prevailing wind direction should be taken into account.

From the photographic results of MB II Events, where charges of 120 tons were detonated, it appears that distances of over 25,000 ft (7620 m) would be ideal for 0-300 s coverage if camera stations were located down wind of SGZ and at angles of 90 to 120 degrees.

The MB II data presented on the effects of AN/FO particle size and fuel-oil percentage indicate that charge composition has a bearing on the explosive-output as was verified by photographic and photometric data.

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APPENDIX

The Appendix contains the table of contents and list of illustrations from AFWL-TR-79-149 on the "*Photographic Documentation of* MISERS BLUFF I and II Series", June 1979. In addition, a figure on the plan view of three cloud camera stations for MISERS BLUFF II Events is presented.

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LIST OF ILLUSTRATIONS (Continued)

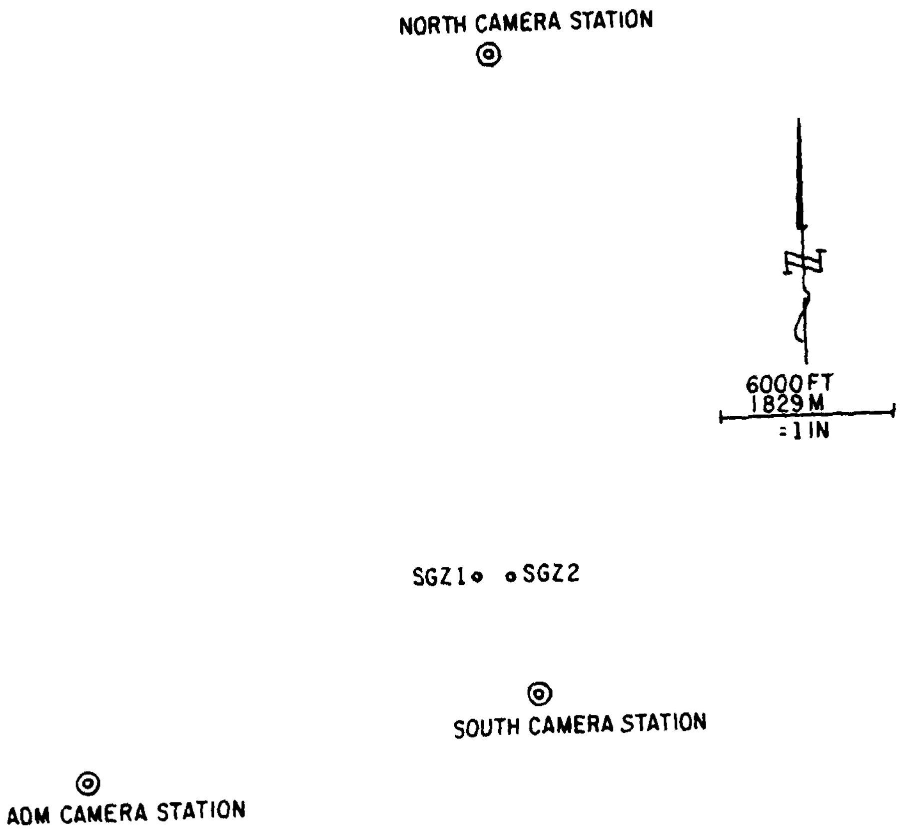

FIGURE 1A. PLAN VIEW OF THE RELATIVE POSITIONS OF THE MISERS BLUFF II CLOUD CAMERA STATIONS.

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